Forest and Water.

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GRIZZLY GIANT

Height 234 feet; diameter 35 feet; lowest branch 100 feet from soil: Showing how this Species, Sequoia Gigantea, Dwarfs the other Magnificent Sierra Forest Trees

Forest and Water

BY

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With Articles on Allied Subjects
BY
EMINENT EXPERTS

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CONTENTS

INTRODUCTION.

There is a notable lack of forest literature in the English language Recent works on Forestry in English are the "Primer of Forestry," a public document and a most valuable work by the Government Forester, Mr. Gifford Pinchot, and a volume received by us, as this treatise is going through the press, entitled "North American Forest and Forestry," by Ernest Brucken. The circulation of other works has been inadequate to awaken any general interest. Yet in the Far West, forestry is closely related to the development and to the life of the country. The improvements and occupation of the vast empire of the arid public lands are dependent upon the preservation of the water-holding power of the forests on the mountains. These are the natural reservoirs.

In the Western Forests the prevention of torrents and the preservation of perennial water supply overshadow all other forest questions, except in the western part of Washington and Oregon and in Northwestern California. In these districts the timber supply is paramount. The rapid exhaustion of the Forests in other portions of the United States is forcing attention to this rich timber resource. It is a pleasing thing to note that the general tendency throughout this district is toward a more rational and scientific system of lumbering. There is plenty of room for improvement. The lumbering in these superb forests has been on most reckless and wasteful methods. The forests have been cut and burned without regard to the future, neglecting even present safety.

Sheep packing Forest land so that it sheds water and cannot absorb it is demonstrated by the practice formerly prevalent in Southern California of puddling and rendering the reservoir bottoms water tight by driving sheep into the excavations. This method was effective. From this we can perceive the effect of large bodies of sheep on watersheds. Fires diminishing water-holding power of mountain water sheds is well understood by all forest students. There is another effect that has been recognized in Southern California by a number of careful observers and carefully checked up. This is the cementing up of our torrent-cones by the ashes washed down from the mountains after fires. This detritus fills the interstices of the gravel and sand and

thus allows the water delivered to flow across and beyond the great natural reservoirs of our largest springs and streams. These are what we call the second tier springs. One of the largest of these is a tier of springs supplying the Los Angeles river and constituting the domestic supply of this large city and of the irrigated vegas to the south. Whenever a watershed is burned over we see the mountain streams extend their flow beyond the usual limits because of this channel cementing. Thus on a light rainfall we see streams flowing clear across the natural reservoir when without such fires only long and continuous rains produce this result. In this country it is a misfortune to have storm water flow off. We want it to sink in so that the perennial springs can be supplied. It requires a heavy flood rolling the gravel and boulders about to break these ash-cemented channels up so that they can again absorb the torrent flow. This is one of the serious dangers growing out of our mountain forest fires. The watershed fires affect the first tier of mountain springs disastrously. The reduction in permanent water flow from these springs by such fires is from one quarter to three-quarters of the regular supply. Comparing the flow from the Deer Creek Springs with water-shed unburned with springs on each side of it and on burned districts for the past two years of light rains we find a slight shrinkage in the Deer creek supply and a frightful shrinkage in the springs from the burned water sheds. The exact figures are: Burned watershed, Cucamonga Canyon—Ordinary flow, 210 miners' inches; after fire, reduced to 29 inches. Burned over and second growth again burned on Alder canyon—Former flow, 6 inches; after fire, 0—or absolutely nothing. Deer creek canyon, unburned, ordinary flow, 48 inches; in present dry year flow, 40 inches.

These and other cognate subjects on which I have extensive notes are more fully discussed in this volume under appropriate heads.

Tree planting in Southern California has been more general than in any district with which I am acquainted. The entire aspect of the country has been changed. The objects of the forest tree planting were for roads, wind breaks and fuel. At present the large eucalyptus groves have become valuable for piling. The leaves of the Eucalyptus are also used by several local establishments for the medicinal oil and for eucalyptol. These trees and the Acacias grow with wonderful rapidity and insure a fair fuel crop at seven years and a good one at ten years.

The Forest societies of the South have this year started to replant portions of the burned areas of the Sierra Madre with indigenous

forest. This is being done by seed planting. About seventy thousand seeds will be set out. This work is in charge of Mr. T. P. Lukens and immediately under the auspices of the Los Angeles Society.

Mr. T. H. Douglas of the Waukegan Nurseries gives an encouraging report on forest tree planting in the Middle West. Railroad companies appear to be the largest planters. Mr. Douglas has been unable to give me the statistics of forest tree planting in his section, but he reports the interest to be increasing. This year he says the largest demand for seedling forest trees within his experience has occurred.

The distinguished writers and engineers who have contributed to this work speak for themselves in their chapters. Every forest lover will thank them as I do for their work and co-operation. Special thanks are due to Prof. W. R. Dudley, holding the chair of Botany at Stanford University, for his aid in the chapter on trees of the Reserves. Dr. John Woodbridge. of South Pasadena also receives my hearty thanks for his arduous work in the detail and editing of this book.

Los Angeles, September, 1900.

NOTE.

ARIZONA PETRIFIED FOREST.—Lest mistake be made in regard to the age of the Arizona Petrified Forest alluded to in this work, the following note is made :

These stone trees of agate, amethyst and other beautiful crystalizations, that have replaced the wood tissue, grew in the Mesozoic age. Buried in ancient seas they were covered and petrified. The bed of this ancient ocean was raised. Untold ages of erosion have brought these beautiful and strange mementoes of an extinct forest again to light. Geologists estimate that the age of the petrified trees approximates fifty million years.

Forest in Sierra on Granite.

FOREST AND WATER.

CHAPTER I.

DEFINITION AND HISTORY.

Forestry is a broad term covering the subject of forests in all respects as they exist in large outlying and uncultivated districts. (The Latin Foris—foresta.) Questions of every sort connected with the natural growth, care and uses of forest trees appeal for answer to the forester and subjects allied to forestry occupy many fields of thought and study.

The origin of forestry may have been in man's instinct. There was a point beyond which forest destruction was man's destruction. Amongst primitive men, game and fish and the natural products of the forest glades and streams formed their food resources and in fact all their resources. These resources required large forest areas for their life and reproduction. This reason for the evolution of an instinct for forest preservation was in addition to the less proximate one of the destruction of the earth's life-supporting power growing out of undue forest denudation.

The instinct in favor of trees was first formulated in primitive religions. Trees were made sacred in themselves at first and later groves became sacred to both religion and learning. Religious feeling favorable to trees is still perpetuated in Gothic architecture. The great Gothic cathedrals of Europe are in imitation of great forest groves. Their interiors clearly show this origin. Learning in early times was a religious monopoly. We have the Greek word "Academy" meaning a grove to perpetuate the connection of forestry with learning.

In Mediaeval times forestry was perpetuated by the Kings and nobles for their hunting and pleasure. These forest reserves were found to have

other value. Their products could be taken and sold under judicious restrictions without injury to them as game preserves or to their permanence as forests. Here we find the first evidence of the use of forests as a continuous source of revenue. Both kings and nobles counted their forests as income bearing resources. The evolution of European society gradually diminished the value of the feudal system and finally made it an impediment to human progress. The power of the nobles went first and that of kings or hereditary rulers is gone in some countries and with the present social movement continued, will go everywhere. With the elimination of the useful action of the feudal lord went his fortune also. Forests were sold for court expenses or other extravagance. These forests were first cut off and then in many cases entirely destroyed as to new growth by continuous sheep pasturing.

RESULTS OF FOREST DESTRUCTION.

Observers and travelers had already commenced to note the serious results of forest destruction in the sixteenth and seventeenth centuries. Men like Arthur Young have left us accounts of what was happening in Europe at that time. The center and south of France and Spain are the principal countries in which injury was then noted as resulting from forest destruction. The creation of torrents and intensification of flood action and the reduced navigability of rivers due to deposits of detritus and diminished perennial flow of water were first observed. Later came the appreciation of climatic change, especially the increase of frosts and warm winter spells. These changes continually moved the northern limit of profitable growing of various fruits and crops to the south. Amongst the more notable instances of this is the shrinkage of the olive-growing area in France. At the time of the French revolution the causes of forest destruction were rapidly increased. The lands of the nobles were appropriated and forests were cut wherever there was a market for wood. This market was best of course in those districts with the least wood—the very ones where the forests were at a minimum and where in many cases the forest cutting meant total denudation of the water sheds. The results of this forest destruction were disastrous in Provence. Districts were depopulated, extensive productive areas became deserts of wash, boulders and detritus from torrent action and the productive output of the district was materially diminished. It was a series of such serious results that finally forced the great central European powers into a rational system of forestry. Commencing with France forestry has spread even to India

and Australia. Canada has a fair forest system. In fact about the only civilized country in the world today without a forest system is the United States of America.

SYSTEMATIC FORESTRY REQUIRED.

The attention of Central Europe once attracted to the need of rational forestry the students of forest conditions commenced to note the disastrous results of undue forest denudation in Persia, Palestine, Macedonia, Greece and North Africa. Every series of observations showed the need of rational forestry. It is now admitted to be established that every country requires a certain proportion of its territory to be reserved in forest for the highest productive agricultural results. This proportion to preserve in forest varies with the topography and climate of the country. As to Europe, it is now the accepted opinion that the minimum forest area requisite for the largest agricultural produce of the whole country is one quarter. Southern California, like all of our semi-arid territory, has far less than this proportion of forest and has immense desert territory in proportion to its productive area. We certainly cannot safely reduce our forest area at all.

In the United States forestry has been discursively discussed since 1834 and even earlier. In 1885 California established a State Board of Forestry. This was an attempt in the United States to deal practically with forestry. This board did a great deal of good work. Amongst the things it accomplished were the following: Making forest maps of the State based on actual surveys; botanical and popular account of all native trees of California; examination of lumbering; methods and saw value of timber; presentation of results of torrent action and reduced springs consequent upon forest fires in Southern California; introduction of exotic trees suited to California, especially species of eucalyptus; arrest and prosecution of those starting forest fires; stopping of unauthorized timber cutting on public lands.

Under Governor Waterman the Board of Forestry was used for the reward of political partisans and neglected forestry entirely. The Board was shortly after abolished and its experimental forest stations and property were turned over to the University of California. Nothing has been done for forestry by the State since, but the work done by the State Board did great good. Its efforts helped the movement which has resulted in the reservation by the Federal government of nearly all the important mountain water-sheds south of Lake Tahoe

No. 1

No. 2

The Forest at Mt. Shasta.

No. 1 is from a photo taken in 1887, Before Lumbering. No. 2 was taken in 1892, After Lumbering.

By courtesy of W. H. Mills, Esq.

in California as forest reserves. Last year (1898) was the first time that the Federal government has recognized its duty to manage and care for these reserves. While the patrol appointed under the usual political methods was imperfectly organized and not effective, still it was a step in the recognition of a plain duty.

We have opened in Los Angeles this year (1899) the first forest school in California; the first on the Pacific Slope, the first west of the Alleghenies. It is an auspicious event and hopefully the precursor of a new era. It is high time for us to make a study of our forests and of their importance and proper treatment. We are without foresters in America. We need foresters.

The forest conditions of California and the arid West are different from those in any other country. They are entirely different from those of the Adirondacks where the Cornell students are studying and where they will be employed. They are different from those of Biltmore, N. C., where apprentices are taking up forest work. Our conditions both of water-sheds and forests, of climate and government organization are so different from those of Europe that an educated forester fitted for European work would have to learn much of his business over again to be fitted for California work. There is then a need of foresters educated to meet California and Western conditions. There is from this fact the promise of a career to young men in taking up this work. The study of Forestry ought to find a place in every State of the Union.

Next year we hope to have the students of the Los Angeles school recognized and made the basis of the local forest patrol.

CHAPTER II.

PRACTICAL FORESTRY.

ADVANTAGES OF FORESTED WATER-SHEDS.

Forestry has two distinct objects:

1st. The management of the forest so as to secure the largest returns consistent with permanence of crop. Under such a system the ripe timber is judiciously marketed and the other products economically treated.

2nd. The guarding of water-sheds as natural forest reservoirs to secure perennial flow of springs and streams and to prevent torrent and flood action.

A denuded water-shed delivers the rainfall on it suddenly and always with detritus, such as sand, gravel and boulders. This fills the lower channels and is often deposited upon agricultural lands to their great damage. This is the feature of forestry that is of paramount importance to Southern California and to much of the arid West. To these main objects of forestry there are cognate interests that may properly come within the scope of forestry. Of these the provision for mountain resorts and for the preservation of fish and game are of importance to us. But the most important is the storing of the surplus winter rains in artificial reservoirs. The Federal government is committed to this action. It has reserved numerous reservoir sites in Southern California from sale and private development. It is consequently bound to go on and provide these reservoirs for the development of the country. Under a judicious land policy this can be done without any permanent cost. The increased value of otherwise desert lands will pay for the reservoirs.

FOREST DESTRUCTION AFFECTING RAINFALL.

Amongst matters that must be considered in the study of forestry is the effect of forest destruction upon the rainfall. This is still an open question. Does forest destruction diminish the rainfall is one question, and another in this connection is: Does forest destruction change the character of the rainfall? Does the rainfall in denuded districts become more diluvial than when these were forested? Other questions for our study and investigation are: The delivery of rainfall through forest leaves and branches to the soil; the evaporation area; the retentive power for water of the forest soil mixed with humus; the detaining effect upon rainfall off-flow of forest humus, leaves and roots; the electrical effects of forests; the chemical effects upon air and soil of forests; the climatic effects of forests; the radiation of heat from forested as compared with bare areas; the effect of forests on winds; botany, geology and biology all come into the study of forestry. Replanting desolated districts and the selection of trees for these must not be overlooked.

QUESTION OF TORRENTS.

The immediate and paramount question for us now in Southern California is the prevention and extinction of forest fires. A close second to this is the management of torrents already created and the prevention of these in the water-sheds where they arise. In the Austrian Tyrol the policy of diking and valley protection has been followed to deal with the dangerous torrents, while in France the policy has been more to extinguish the torrent by dealing with its source. These methods we will contrast. In dealing with all these subjects remember that it is our own eyes with which we see. We have the opportunity like all students of increasing our horizon by mounting on the shoulders of those who seek to instruct us. Or to take another simile. They who address us are in resemblance to sign boards on roads. They point the way, we hope the best and shortest way to the goal, but it is we ourselves who travel the road. We will never reach the goal by simply sitting and studying the sign boards.

I have been around the world, yet I have never seen elsewhere a union of fertile soil, steep boundary mountains, delightful climate and light rainfall with periodic diluvial downpours such as exists in Southern California, nor have I seen elsewhere any land so clearly demanding protection and management of mountain forests. Forestry here means the life of the community.

Redlands Rescued from the Desert by Irrigation from the Sierra.

CHAPTER III.

ORIGIN AND CONTINUANCE OF FORESTS.

In the study of forestry it becomes a matter of interest to inquire into the conditions under which a forest can come into existence. The theory of evolution takes us back to the single cell from which to imagine the building up of cells and combinations of cells into our tree growths as a preliminary to past and present forests. A long and interesting inquiry opens along these lines. While the evolution of our trees from simple vegetable forms or from the cell is not proven the theory follows the lines of least mental resistance. Besides this, evolution offers us a reasonable hope for further development and improvement for life especially in its human form. This adds greatly to the attractiveness of the theory. If life has evolved from the single cell to the present varied and complex forms it is easier to assume further progress than to assume that life has reached its highest limit. With this doctrine we have a just expectation of better things for our descendants if not for ourselves.

The first land that appeared in this world could not have had forests on it "ab initio." We must take a mental flight from the times of the first appearance of land, covering aeons of time, before we can arrive at forests like those we now have. The erosions and vicissitudes of tide, flood and tornado in the earliest history of the earth's land would of themselves preclude at that time the possibility of any forests whatever. We are forced to the opinion that great extremes in these matters of air and water movement existed. How vegetation first had a start and hold on land is an interesting subject for speculation. It is probable that the conditions under which the earth's life, including vegetable life, took its evolutionary initial movements no longer exist. This presumption is probable as to all present forms of life. If the world was without life today it is reasonable to assume that any life developed would be in

entirely different form from forms now existing. In fact the earth has probably passed the point where life could originate at all. The first conditions under which vegetation occurred were doubtless such as to have proved fatal to later and especially to present forms. It is not only the extraordinary tidal action and storm power but also a probable difference in the chemical composition of the atmosphere that would have made primitive conditions fatal to present forms. The violent and frequent upheavals and subsidences that the location of the coal strata demonstrate to have taken place during the carboniferous epoch indicate a rapid growing and dense forest and one taking possession of new soil easily. These coal forests were of a different character of growth from any forest now existing. They were probably produced on alluvial deltas subject to elevation and submergence and to a coincident heavy deposit of detritus during the periods of subsidence. Thus the fern like forests grew, were destroyed, were covered with rock-making detritus, were compressed and carbonized and then the delta elevated above water again produced forests; and again going through such histories we find veins of coal alternating with veins of rock one above another. We can then feel confident from the rock records of the coal forests that a forest destroyed may be renewed by natural means. In fact we know that in most forested districts a mere absence of human action will insure a new forest growth. Perhaps this growth will not be as valuable as the primeval forests but for its effects in conserving the water holding power of water-sheds there would be little if any difference. Man by aiding nature can increase the certainty and rapidity of reforestation. He can also secure a more valuable crop and determine what the forest shall be within limits.

A FOREST DESTROYED MAY NOT ADMIT OF RENEWAL.

We noted the presumption that conditions in the world were changing. However slow these changes are we cannot escape from the conclusion that changes are going on. There comes a time then when conditions may be so close to the limit of permitting forest life that a very slight change may determine the issue. The change may be so slight that man or animals may make it. That a time does come in changes of climate and perhaps in other conditions when a forest destroyed cannot renew itself nor be replaced by any growth is subject to positive demonstration. I have visited two petrified forests in which the stone trees lay thick on the desolate desert valleys. These petrified trees

Petrified Forest in an Arizona Desert Demonstrating Former Presence of Forest there.

produced beautiful sections when cut and polished. One such petrified forest is in the Sahara in Africa and the other in the Territory of Arizona. In these cases forests had existed where there is now only desert.

A modern instance of somewhat similar purport is the burnt and dead forest on a southeast spur of San Bernardino. This forest was killed by fire nearly fifty years ago. It is now without renewal. Valuable forms of our forest vegetation in Southern California probably had their origin somewhere else and have been introduced here from the north. It is reasonable to assume that all forest forms were evolved on comparatively level plains and that mountain forms have been modified by slow elevation and change of climate and condition. In most parts of Southern California we are too near the edge of conditions favorable to forest growth to take any chances on allowing important forests to be destroyed. All our forests are on steep watersheds, all are of the highest importance and therefore with us the demand is for the preservation of all our forests.

Arizona Desert Native Growth.

CHAPTER IV.

PROPORTION OF LANDS IN FORESTS.

In most countries it is reasonable to examine the area occupied by forests with a view to an intelligent determination of how much land is to be or should remain permanently cleared to secure the largest agricultural returns. We have seen that in the countries of the temperate zone this question has been looked into with the average result of a determination that one-fourth of the total area should be in forest for the highest crop results. This determination is without regard to the agricultural value of the land held in forest. In other words one hundred million acres of agricultural land in a body would produce more annual crop for periods of ten years with one-quarter in forest than all under the plow. Topography and climate alter these judgments. An amount of clearing on level land that would be advantageous to the general producing power would on steep mountains like our Sierra Madre be without any possible benefit and would be certain to increase torrent action and diminish springs, and so diminish the output of the true agricultural lands.

If we should take the east line of the principal mountain chains of Southern California and consider the land between this and the Pacific ocean we will realize what a large proportion is unavailable for agriculture because of its mountainous character. Part of these mountains is covered with chaparral or brush; part is in trees and another part is either very scantily and scatteringly covered with brush growth or is bare of any verdure at all. The nearer the sea, other things being equal, the denser the growth. This growth is usually brush on the lower hills and mountains. On the higher levels open forests of spruce, pine, fir and cedar exist. The golden live oak is prominent on the lower edge of these forests and is replaced by the black oak higher up. Portions of this mountain area, always above the four-thousand-foot level, show a promising tendency to renew themselves in forest when occasion occurs to

Sierra Madre Range. This Range is as devoid of Level Land as any Range in the World.

invite it. Over another section the tendency is for brush to take the place of trees destroyed. This is also the case in considerable sections of the Sierra Nevada on the east face of the range. Again there are districts in which the reproductive power of trees and brush are both weak or are entirely absent. The nearer the desert the more this reproductive weakness is noticed. On the east side of the mountains of Southern California the State is desert with an occasional oasis. This desert may be divided into two broad divisions.

1st. The high plateau of the Mojave. In this desert the rainfall is greater than in the Colorado. Some years there is considerable feed. Toward the west the rainfall is from time to time sufficient for field crops. The extremes of temperature are very considerable. This desert is both very hot at times and very cold at other times. Irrigation has been commenced in several sections of the Mojave. The streams used come from the forest reserves. Big and Little Rock creek and the Mojave river are the ones used.

2d. The Colorado desert. This is much lower than the Mojave—considerable areas being below sea level—and while hot for eight months it is not so subject to cold. There is great promise for parts of this desert to become productive. These parts are alluvial deposits of the Colorado river and to them its waters can be conducted. There are also districts in this desert with artesian water and others subject to development by streams like the Whitewater.

ALL AVAILABLE FOREST LANDS REQUIRED FOR IRRIGATION.

Taking the north line of Santa Barbara and Ventura counties continued northeasterly along the summit of the Tehachapi range to the north line of San Bernardino county and thence to the Colorado river as being the natural north line of Southern California we will consider this territory as segregated from the rest of the State. It requires special consideration. About one-ninth of this territory under present conditions is susceptible of profitable crop bearing. The large results from this comparatively small area under plow amounting now with a fair rainfall to about 25 million dollars a year indicate the value of our deep lands, sunshine, mild climate and system of irrigation in giving profitable agricultural returns and large product from a small district. Two-thirds of the area is desert. One-sixth is in forest, including brush from 4 to 15 feet high. We are thus seen to have already far less than the proportion we should have in forest for the temperate

3

Backbone of Sierra Nevada.

region. Besides this we are on the limit of sufficient rainfall which condition should call for a higher forest proportion than that accepted for districts with larger rainfall; a proportion limited practically by the possibilities of forest growth in the Southern California Sierras. The topography is mountainous with many small and a few large valleys. The forests are all on the mountains. This is where the forests should be and is where they are most needed and can do the most good. In our steep Sierras with heavier rainfall than that of the valleys it is of the highest importance to preserve and extend the forest covering to secure a perennial delivery of the season's rainfall and to prevent the rainfall from becoming destructive in flood and torrent. None of these mountain forest lands are available for agriculture. There are valleys here and there in the mountains with meadows or capable of supporting a few fruit trees such as the apple but in a general way there are no mountain ranges in the world with less possibility of agriculture than the Sierra Madre.

CHAPTER V.

DESTRUCTION OF FORESTS ADMITS NO ADEQUATE COMPENSATION.

The destruction of our forests began with the earliest settlement, when our forefathers first landed on the Atlantic coast. They must clear the trees from the land in order to grow crops for food, and there was no way the ground could be cleared so cheaply and quickly as by fire. This method was adopted, and no effort whatever was thought necessary to confine the fire to the little farm, but the destroying element was allowed to burn itself out. They believed the forests were inexhaustible, and there was formed the habit in America of destroying the forests. Notes of warning have been frequently sounded by thoughtful, observing men, in the past thirty years, that the supply of lumber would soon be exhausted, unless greater care be exercised in preventing waste, especially by fire, and that a tree should be planted for every one removed or destroyed. Thus the impression is held by many that the commercial value of the forests alone is to be considered, when in point of fact, the loss to the agricultural interests, especially in the arid and sub-arid regions is far greater than could possibly be from a commercial standpoint. Many substitutes are found for the uses to which lumber is put, but the certain diminution of the rainfall following the destruction of the forest covering, means the failure of crops. The mountains covered with trees and brush are the natural and best conservers of water, but denuded, are a dangerous factor. While the rain fall will be much less, it will descend in torrents, but little remaining to percolate into the mountains to supply our springs for irrigation. There are so many illustrations of this, that nearly all agree to it.

A writer recently cited the fact that many of the eastern rivers flooded their banks nearly every year, doing great damage to property, while in the rainless part of the year the same streams are fordable where they were once navigable for large steamers. The cause was plainly apparent when investigation was made along these streams, and especially in the mountainous regions at their sources. The forest covering had been removed, and there was nothing to hold the rains in check, consequently the floods,—and nothing to shelter the surface from the evaporating winds and sun, consequently the scarcity of water in the streams out of the rainy season. And the farm that half a century ago produced a good crop nine years out of ten, now is producing one good crop in three, owing to the lessened and irregular rainfall, caused by the destruction of the forest covering.

The great destroyer of forests is fire, and it must be prevented. Next to fire, sheep; where they are permitted to range in our mountains, especially where it is precipitous, they do untold damage. They not only eat or trample to death every living thing, but they start rocks rolling down the steep slopes, until every little shelf where soil had begun to accumulate, and had given a home to a tree seed, is broken and tumbled, until the whole steep surface is smooth with no lodgments, nothing but a thick, smooth surface for the rains and melting snows to gully and run over, leaving no water for summer use. In a country where there is excessive rainfall, extending over the greater portion of the year, as in Oregon, it matters less, but in Southern California, where our rain fall is slight, and the sunshine so predominant, it is useless to attempt to re-forest our mountains, if sheep are permitted to be upon them. There is no possible excuse for fires in our mountains; every fire that is permitted to get out and destroy the mountain covering, is the result of criminal carelessness, and can be prevented in a great measure by inflicting severe punishment for every offense. But when the growth has been destroyed, however reprehensible the act which caused it, there should be no time lost in replanting.

It is as practical to re-forest our mountains as it is to re-stock with fish our depleted streams, though much more expensive. The German government has found it directly profitable, or at least self-supporting.

The seed will be planted generously at first, and as the trees begin to crowd each other, a portion can be removed, with benefit to the whole.

While there is a struggle for supremacy in the growth of any one

Overlooking Grand Canyon of the Colorado, Showing the Wild and Desolate Character of the Country in that Region.

species, there is a far greater struggle between different species; therefore, the best results can be attained by planting the species apart ,and before this struggle becomes pronounced, they must be assisted with good judgment so as not to retard growth by over-crowding, but the value of keeping the entire surface covered is apparent, to protect from the winds, and to prevent the growth of inflammable brush. The importance of quickly covering the area made naked by the fire must be apparent, for the winds and floods will in a decade or two have removed the little soil that escaped destruction, leaving naught but bare rock.

It would be folly to plant any species not indigenous to the locality, or to similar conditions as to character of soil, altitude, climate etc.

NO REASON FOR DESTROYING THE FORESTS.

There is no interest here in Southern California asking for or seeking the destruction of our forests. The policy suggested by some Northern persons of constant consecutive fire setting in the mountains on the claim that an annual forest fire does little or no damage and that fire cannot be kept out of public forests entirely and that therefore where the fire is not annual it must be more destructive has no bearing on Southern California. Our forests are largely chaparral. Fire destroys this brush if repeated twice after short intervals. The chaparral once destroyed we have bare and arid hills and mountains. Artificial planting or impossible periods of years for renewed soil and renewed growth are our only hope after successive fires kill the brush roots. Whatever interest this fire setting theory may develop for other sections it can have none for us. Southern California has no capital or body of people asking for the destruction of the forests or excusing any of the practices that are deemed injurious to them. On the other hand we have for the primary friends of forestry every resort owner in or near the mountains, such as the Alpine Tavern, Mt. Wilson, San Antonio Canyon, Squirrel Inn, Seven Oaks, Bear Valley, Fredalba, Strawberry Valley, etc.; we have every irrigating and domestic water company and every power company representing millions of money and the prosperity of 300,000 people. As secondary friends every city, colony and fruit orchard, every valley land owner, merchant and every city and transportation company is vitally interested in the preservation of our mountain water sheds. This means the preservation of the productive power of the country and consequently of its power to support all the interests in it.

Without enemies and with nothing but friends forestry ought to have a progress and place in this community held by it nowhere else. The policy of Southern California is perfectly clear. We must preserve our forests. Without hostile interests, with no great combines of vested right to do a wrong against a rational forest management, we have only to make these facts clear to the federal authorities and to overcome the inertia of official routine to succeed in our work. The cost need not be large for such management. Less money than was spent last year in putting out fires by the Federal government could have entirely prevented any serious forest fires that season. The system of permit and patrol will do it. The beauty of our country is no negligible quantity. We hold in Southern California something in climate as near perfection as humanity can hope for on earth. Not only do we offer cities of refuge from the relentless frost king to the winter frozen world, but we also offer the unique condition of delightful refuges from the fiery breath of the desert and the long fatiguing heats of the interior. It is estimated that climate tourists spend about ten million dollars a year in Southern California. To these people the beauties of California are no small part of the charm that attracts. Let us assume that the conditions now present on some spurs of our Sierras and due to fire were general to all the ranges. Then we should have hill, Sierra and peak an arid desolation showing a blackened face to the sun. Compare this with brush covered mountains with the canyons lovely and picturesque and the higher districts well forested with spruce, pine and fir. For beauty alone and beauty considered only as a commercial asset we should put an end to the folly of forest fires.

Desert of Arizona, as taken from a Rock Cave.

CHAPTER VI.

FOREST FIRES.

Fire is more dreaded than any other destroying agent by those interested in forests. Fire is more dreaded in fact than all other forest destroying agencies put together, though in California forest fires are regarded differently by different classes. It is well for the forester to have some knowledge on this subject.

WHO OPPOSE FOREST FIRES.

The following enumeration has exceptions but may in general be deemed fairly accurate. The student, philosopher and statesman are all opposed to forest fires. All water companies, all irrigators and all water power companies are opposed to forest fires; all mountain resort owners are opposed to forest fires; all residents and land owners along rivers subject to overflow or used in navigation or on dry washes and torrent beds are opposed to forest fires. Railroad owners are opposed to forest fires, but are not active friends of the forest. Newspaper men have recently enlisted as active friends of the forest and are consequently hostile to forest fires. The farmer is opposed to forest fires, but without much enthusiasm. The general body of the people is hostile to forest fires and favorable to forest preservation; usually more for sentimental and aesthetic reasons than for economic ones. Lumber men are as a rule opposed to forest fires.* Miners are hostile

*Location and climate modify their interest in respect to fires. In the redwood district, for instance, fire set after the trees selected are felled is a part of the lumbering process. The climate is there cool and damp, the green redwood timber will not burn and the undergrowth that will burn is dense. In that district, therefore, the danger to merchantable timber cut or uncut is slight and the clearing by fire of the undergrowth facilitates the mill man's work. The redwood belt condition is exceptional. Owing to the practice of firing as a part of lumbering

to forest fires and actively say so. Placer mines are of course especially so. These all depend on the water in the streams or stored in their reservoirs and conducted sometimes 50 and 60 miles to be used for the continuance of their business. The prospector, however, sometimes sets forest and brush fires the better to study a country. Outside of this one interest of study in a new district the prospector is also extremely hostile to forest fires. He loses feed for his horse or burro. Pot hunters sometimes set fires to move game. These people are, however, scarce in California and confined almost entirely to duck and bird shooting. Sportsmen are all opposed to forest fires. Cattle and horse owners and herders are as a rule against forest fires. They usually own more or less land in the districts where their animals graze and consequently have an interest in other forest lands on account of their own holdings. These herders are for the most part intelligent men and very rarely live less than two or three together. Occasionally the cattleman sets fire to brush hills to improve cattle feed. A few cases are reported of cattle men setting fires in the Sierra and in the San Bernardino range for revenge against other mountain occupants. Sheep owners are opposed to early season forest fires but some advocate and instruct herders to burn off districts in the mountains after the sheep are taken out in the fall. The herder of sheep is a careless and irresponsible person living alone and from his habits and indifference the probable source of more forest fires than all other causes put together. Tourists and campers are opposed to forest fires but are often careless and cause much damage.

It is seen by this resume that the forester has after all only a small and unimportant element that is now favorable or even neutral on forest fires. On the other hand the largest and most powerful interests are opposed to forest fires and some of these are intensely opposed to forest destruction by fire or otherwise.

After scientific study and a demonstration of what is best for the mountain forests, for their highest use and for the protection of mining and agriculture from water famines or injurious floods we may

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in the redwoods there are in that tree belt some of the ugliest scenes of forest desolation to be found anywhere. I have visited lumbering districts amongst the redwoods that made one think of the wreck of the world. A great deal of lumbering in this country is still done upon King Louis' doctrine—"after me the deluge." In these cases the lands are cut over and abandoned to the tax collector.

Forest Fire in the Sierra Madre. Photograph taken Ten Miles from the Fire.

reasonably assume that the forester will find no class in favor of the irresponsibly-set forest fires of the present. Forest fires today are the outgrowth of ignorance, reckless indifference or criminality.

HOW FOREST FIRES ORIGINATE.

In the Eastern and in the Southern States especially locomotives often originate forest fires. This is seldom the case in California. The difference is due to the following points:

1st. FUEL: This in California is nearly all coal or petroleum. Where wood is used the districts are the least dry in which railroads run.

2nd. CLIMATE: The long season of sunshine and absence of rain renders everything in California very dry. Field crops are dry before gathering especially the vast acreage in grain is every summer especially liable to fire. For this reason railroads running through these districts are unusually careful about cinders and fire from their locomotives.

3rd. The care required to protect bridges, culverts, trestles, timbered tunnels and snow sheds protects the forests also. The locomotive is not an important source of forest fires in California.

The causes of forest fires in California are estimated to be as follows:

1st. Sheep herders, mainly carelessness, also to improve feed for next year.

2nd. Campers—carelessness.

3rd. Mountain residents to clear off undergrowth and improve feed for small local bands of animals.

4th. Stockmen—same.

5th. Various persons for malice or revenge.

The reports in regard to some of the temporary fire patrols, both of last year's government forces and of some of those sent out the year before by water companies along the Sierra Madre, invite us to add another cause for forest fires. This is the irresponsible political loafer about street corners, setting forest fires to get a job to put out forest fires. No proof of this has been adduced, but there is a good deal of cumulative circumstantial evidence that forest fires were set and were reset or renewed by those seeking to be or in the government pay as fire extinguishers. This cause, as far as it exists, will be eliminated by a proper organization of the forest patrol force.

Forest Fire in Sierra Madre Mountains, July 22, 1900. Taken Twenty-five miles from fire.
Prof. A. J. McClatchie, Photographer.

CHAPTER VII.

FOREST FIRE DISTRICTS.

From a forest fire point of view, California should be divided into at least three districts, viz.:

1st. The Redwood belt, along the Northern Coast.

2nd. The Sierra Nevada.

3rd. The forests of Southern California.

The first district is in private hands and has no government reserves. The climate and principal tree growth being less dominated or subject to fire than our other forest climates and woods, remove this district from as immediate an interest to the forester on this subject as the other two have. For our Southern ranges in general, fire prevention is our only policy.

THE SECOND AND THIRD DISTRICTS CONSIDERED TOGETHER.

The statements of early visitors to these forests, the statements of Indians, and the condition of the forests, all go to show that the Indians habitually and regularly burnt the forest floor of parts of the Sierra Nevada. In the Yosemite Valley, where there are black oaks the acorns of which are sought by the Indians for food, there was a regular Indian clearing system. Every autumn the valley was put under the charge of four captains by the chief for the purpose of burning it over. When the whites first visited the valley they found it an open meadow, with only a few large trees in it. Under the whites the fires have been kept out. The result is an invasion by the forest into the valley. Entire sections have grown up to dense forest, and from year to year the remaining meadows were encroached on until some disappeared and all were reduced. This continued until the views in the valley were much masked. The landscape treatment necessary for a park like the Yosemite demanded that the views should be opened. Two years ago the State undertook this landscape work, spending about seven thousand dollars in the most important clearings.

Chaparral after Fire, San Gabriel Reserve.

This did much for the beauty of the valley, and was essential long before it was commenced. In the Hetch-Hetchy valley, a similar granite chasm near the Yosemite, the old clearing method was continued much longer than in the Yosemite, and after the Indian rule heavy stock pasture continued to keep the trees down. In that valley the meadows have remained open as they were at first. It is less certainly reported that the Indians, at least every few years, burned over the forest growth both in the Sierra Nevada, in the oak groves in the valleys, and also in parts of the high Southern Sierra. I have known the Indians fire the pinyon pine groves late in the fall on the San Bernardino range. At General Bidwell's ranch near Chico, Cal., there was a few years ago, on my last visit, a large field fenced in that had been thus protected for a long time, forty or more years I think the General told me. The field originally had been one of the beautiful open groves of large oaks which are such a striking feature in certain of the California valleys. After the fencing a dense growth of young oaks came up. While of the same species, these young trees grew tall and straight, and were in marked contrast to the old trees, heavily branched, still standing amongst them. The young oaks were thick, while the large old ones stood from 60 to 200 feet apart.

The old-timers report that all of the Sierra Nevada forests were open park-like forests, with many meadows and extensive breaks in continuity when they first saw them. Much of the Sierra Nevada forest is still in this form. A great deal of forest territory, however, has a heavy growth of young trees packed closely together under the old ones. This new growth is too thick to make good timber, and is often so dense as to be impenetrable to a man on horseback. Nearly all the mountain meadows and nearly all the old breaks in the National Yosemite Park, where the military patrol has kept out sheep, are being encroached on by forest trees—mainly tamarack. These facts demonstrate that the absence of fires in the forest tends to produce over the central and main timber belt of the Sierra a heavy new growth of coniferous trees. The absence of sheep and fires increases the area and density of the forest in the mountain areas affected. This is probably also the case in the oak lands and lands damp enough for tree growth in the valleys. The presumption from these facts is that the park and grove-like growth of the forests of California when first noted by civilized man, was not a natural growth, but was due to the Indian practice of more or less regular firing prolonged over an indefi-

First Day of the Mountain Fire August, 1898) near San Gabriel Peak

 Third Day of same Fire as seen from Martin's Camp. Point of Commencement on Extreme Left

nite period of time. A second presumption is that as a tree died from age, disease, or other cause, no new tree could take its place on account of the system of forest burning. Therefore, what had made the valley groves open and the monntain forests park-like, would finally have destroyed the forests and exterminated them entirely. If we undertake to imagine the open forests of the Sierra to have been produced by this constant burning, we cannot escape from assuming a long period of time for the production of the result. We cannot but believe that the present features of forest reproduction in the Sierra have existed since the species of trees now prevailing existed. From this we can realize the time of the process likely to have been necessary to produce the present Sierra Nevada forest. A confirmation of the opinion that the open meadows and park-like forests of the Sierra were produced by Indian burning of the forests is found in the oak openings of the central western states, including Tennessee and Kentucky. When the Indians were driven out, and the annual fires set by them late in the fall in these oak openings ceased, the openings grew up to forest just like other surrounding woods. The strong reproductive power of the Sierra Nevada forest, especially throughout the main timber belt, and the way the young trees come up when sheep and fires are kept out, practically force the opinion upon us that the open mountain meadow and open forest are the result of man's work. There is a well-known tendency in dry climates for arboreal vegetation to be scattering and open. This is reasonably assumed to be due to lack of sufficient moisture to support any denser natural growth than exists. In the Sierra foothills we can see this illustrated. The point where trees first commence in these foothills always shows a very scattering open growth that cannot be considered a forest. As the elevation of the hills increases the rainfall increases and the heat diminishes. The tree growth shows the change of climate by an increased density of growth and increased value of timber up to from six to eight thousand feet elevation. At or near the latter elevation conditions become less favorable for trees generally. That point passed, inferior timber varieties take the place of the great Sierra timber trees. This can also be seen in the cross-range of the Tehachapi, where the rainfall is less than in the Sierra Nevada. The tree growth is less dense and of less valuable species at the same elevation in this range. A large proportion of the Australian forests have this open form of growth. We should from these facts reserve our judgment on the cause of the open character generally of the

Burned District Formerly Covered by Chaparral Sierra Madre.

Burned Forest on Right Showing Fire Line to Unburned Trees.

California forests. A long period of survival of the most hardy trees to drought, or the most favorably situated individuals, might produce the same final results of an open forest that the known Indians' regular firing of the forests did in certain valleys, like the Yosemite. The best demonstrated effects of regular forest fires by Indians are in the Sierra Nevada valleys, where the oaks grow producing the favorite acorns of the Indians. Of these the Yosemite is an illustration of what happens when the firing is stopped, and the Hetch-Hetchy of what happens when it is not. The fire means shrinkage of the forest area, with probable final forest extermination. We cannot, therefore, join with some of the old mountaineers of observant qualities in the opinion that a forest firing by sections to secure, within, say, six years, the burning over of the entire area, would be a proper forest policy for the Sierra Nevada. Besides the general objection to this so-called Indian system, there is the expense and damage that would inevitably accompany it. Private interests, mines, ranches, lumber mills, individual holdings, fences, resorts, and even towns, are scattered through the forest districts. These interests are now so general and so much threatened by forest fires that any large forest fire is sure to secure a body of local volunteers to confine or extinguish it. Should the government set such fires it would be responsible for any damage that might be done. There are, however, belts of forest, and especially places on ridges and spurs, that could be safely burned over in the late fall, and after the first rains, without local damage or danger of the fire's escape. Such burned-over districts or ridges would constitute fire breaks. Without recommending definitively such a system for the Sierra Nevada, I am inclined to the opinion that along judiciously laid lines, with a view to the use of the natural topography, fire breaks can best be made by fire. The accumulation of dead wood, windfalls, etc., together with the increase of undergrowth now noticeable in the Sierra Nevada forests, demand fire breaks as a part of any effective forest system. The only other way to obtain these is by hand clearing of the inflammable matter along the lines selected. Even then the piles of waste could not be practically disposed of without fires. The cost would be far greater by hand clearing. The cost of any forest system proposed must not be lost sight of. The cost is one of the main questions. It must be reasonable, and should give fair prospect of being met by the forest receipts.

A resume of the points just discussed gives us the following positions:

Burned Forest.—Courtesy, Gifford Pinchot, Forester U. S. Dept. Agriculture.

1st. Opposition to forest fires.

2nd. Use of fire in forests to control forest fires.

We should not leave this part of the fire question without calling attention to a customary exaggeration of the damage done by forest fires. Several estimates of such damage have been current within the last few years. All of these have been based on a large estimate of the entire forest area, both cut and uncut, over which fire has run during the year, and then taking the ground that wherever fire has run the forest has been destroyed. This is not correct. The majority of forest fires in California do not destroy the forests they traverse. Damage is done and much waste takes place, especially in territory long protected. From time to time important areas of forest are killed out. There is an immense district of dead fire-burned forest in Western Oregon of this kind. I traveled through an extensive fire-killed forest in 1873 in Utah, and have seen many smaller forest tracts fire-killed. The truth is bad enough. We need no exaggeration to impress upon the people the danger of uncontrolled fire.

Showing Line of Burned District.

CHAPTER VIII

PASTURAGE IN FORESTS.

The pasture of domestic animals on forest lands has always been a troublesome question.

Pasturage in forests has been at all times and in all countries a difficult problem to deal with. In Europe the use of forests for pasture persisted for a long time, and in some cases still persists, through the rights of communes holding forest lands in common. This right is that each member of the society could use the forest communal land for pasture.

There were also certain rights of the people under the feudal system to uses of the forests.

Both our laws and customs in this country, dealing with the public forest lands, reflect this older system.

COMMUNAL USE UNJUST AND RUINOUS.

The feeling amongst our people, and especially amongst pioneers, is that the forest is common property. Its values go to the first comer. The first comer can take the wood, or use the pasture, or kill the fish and game. For many years the lumber business was operated on the public lands on this theory. Even recently, lumber companies have cut over immense areas of the public land, without acquiring title to the land. In a case examined some years ago one lumber company, amongst others, was proved to have cut and marketed in this State over two million dollars' worth of timber from public lands, and a proportionately large amount from State school lands, without payment of a single cent to anyone.

The law permits settlers to take from the public land timber for buildings, fences, flumes, etc., for their own improvements. Miners enjoy similar privileges under laws or permits from the Interior Department.

Communal rights in forests, that is, the right of individuals in a community to individually use the forest for personal benefit, is fatal to the forests.

This method of use involves in practice the lack of management. Temporary and small personal advantage is the dominant factor in such use. The general interest in regard to watersheds, renewal of forest crop, etc., are necessarily not considered. The forests should be used. The highest use will and does vary with location. In Southern California the highest use is in the preservation of the watersheds.

The European communal use of forests has been disastrous to both forests and communities. Our communal system has been equally injurious, considering the time that it has prevailed.

Pasturage on the forest lands, held in common by the communes of France, has always been injurious to the forests. It has destroyed the economic value in most cases, and has often resulted in their absolute annihilation.

An incident of this communal forest pasturage has been its rank injustice. Use in common of the forests for pasture has the result of throwing their use to the strongest and wealthiest members of the communes. Of these wealthier members, it is the more violent and least conscientious who get the lion's share. Finally a few get the entire advantage of communal forest uses. This use, however, has proved to be a constantly diminishing quantity. In those districts of Europe that are situated in a climate similar to ours, the end of these methods has been:

1st—The extinction of the forests.

2d—The destruction of the mountain pasturage, after the forests are gone; and

3d and finally—The injury and frequent destruction of the valley lands.

This last is accomplished by the injury of the water supply, and by torrent injury to the land.

The French government has done a hard and constant work to reduce or expropriate these old rights. It has reforested extensive districts, denuded and injured by improper policy, both in sandy districts with drifting dunes and on mountain ranges from which the soil has nearly all disappeared with the forests. There have been national, as distinguished from communal, forests in France ever since the science of forestry started in that country. The present forest laws in Europe,

especially in Germany, France and Switzerland, give a large control to the Forest Departments over both communal and private forest lands. In some cases not a tree can be cut without a government permit. In the United States, the federal public forests on mountain ranges, and, therefore, of the highest importance to the character of water delivery from them, are all in or west of the Rocky mountains. In the irrigàted portion of California the forests are confined to the mountains.

In all these public forests, as on all the public lands, there has been more or less common use of the pasturage. This forest pasture is scant in California. The only districts which have any pasture of importance in our forests are those upon the Alpine meadows of the high Sierra. These high Alpine districts are variable in their contents of meadows. They are calculated to carry an average of five thousand head of sheep, or eight hundred to nine hundred head of cattle or horses to a surveyed township. In a general way, we can say that two acres of this Alpine district will carry a sheep for three months, and about ten acres will carry a horse or steer.

Our American experience has been short in the common use of public forests. As far as it has gone, it has duplicated that of Southern Europe. Everywhere the forests are injured by it. Everywhere the pasturage itself is injured both by premature and by excessive use.

We have had the same result as to the fairness and equality of use as in European communal forests. In our experience, large stock or sheep owners generally parcel these forest pastures out by agreement, and enforce these agreements by armed men. New men, large or small, are trespassers. Their animals are in constant danger, and they often pay the penalty of life in attempts to obtain a share of the common pasturage. When small men come in, it is a question of life and death with them.

While I was in the Sierra Nevadas last year, 1898, there were three shooting affrays amongst rival stockmen within ten days, all in the Yosemite National Park—in which none of them had any right whatever. When powerful interests meet, the result is little short of open war. In Wyoming, a few years ago, the stockmen's war to hold common lands against settlers passed beyond the control of the State authorities and necessitated the sending of Federal troops to end the trouble. The National Parks in our forests have required details of the army to keep the pasture-seekers from irreparable injury to them.

Tax evasion is general amongst those using the public forests for pasture. Use in common of our forests has resulted in cruelty and injustice. It has been almost exclusively for the benefit of the rich and powerful. It has been accompanied everywhere by violence and fire. It has been the occasion of constantly recurring arson and murder. Who can defend such a system? It is no system. It is anarchy, with the true accompaniments of anarchy—FIRE, KNIFE and GUN.

RELIEF FROM THESE ABUSES.

The defense of these uses or misuses of our public forest lands is confined to those engaged in the business. These persons acting together have influenced politicians to prevent regulation or removal of abuses. We must take politics as they are in seeking a remedy. This means an organization of the general public, led by irrigators and intelligent public-spirited citizens generally to show the politicians that the vast preponderance of voting power is opposed to the robbery and destruction of the public forest property. Such an organization will end these abuses. Such an organization is now in process of formation in Southern California. Stock and sheep men are now taking a more intelligent view of the public land question. Nearly all desire relief from the present irregularities and uncertainties. These men endorse a lease system, and admit that exclusion of all stock from some sections is essential for the safety of the public interest.

While we take up this line of practical politics, none of us should overlook the need of modification of our present political system. It is the system that is at fault. It is not the people nor popular government that is more defective than in other times, but the system of getting at the people's will that has been outgrown by industrial changes and by our vast increase and concentration of population. We cannot now go into this question. It must satisfy us to say that human nature has not changed much in the historic period, and that men are at least as good now as they ever were. It is then by a sound, honest, practical system that we will get our best men into public life and get the best instead of the worst there is in a man into use, when he goes into public life.

CHAPTER IX.

PASTURAGE IN DIFFERENT DISTRICTS.

In the San Jacinto range, all the public forest lands are practically without pasture.

In the San Bernardino range, there is no public land that has pasture of value in the forests. There is, however, more or less scattered pasture on private holdings, which, with the customary use of adjacent, unimportant public pasture in forests has brought sheep and stock into the mountains irregularly. The whole of this pasture is of comparatively small value.

In the Pine Mountain reserve, there is rather more pasturage than in the San Bernardino range.

In the Trabuco reserve, there is very little.

In the Sierra Madre range there is very little pasturage, and this little is very difficult of access. This reserve is in our county, and for that reason, we will find interest in going into its pasture question somewhat in detail.

This extensive and precipitous range has not in its entirety as much pasture as a single high Sierra township. From repeated personal visits, I believe it safe to say and well within limits, that the entire range would not carry five thousand sheep or eight hundred horses. If it could carry such an amount of stock, how infinitesimal would be the value of that interest, compared to the value of the interests of the resorts, power companies, and above all, of irrigators on its water-sheds. We still say nothing of the valley lands subject to injury or destruction by torrents. The stock interests in the mountains is nothing. In fact, I do not believe that the entire Sierra Madre reserve could carry two hundred and fifty horses during the open season.

The range has, however, long been used on and off by a few horse owners. Sheep have been a small factor in this reserve. The only occasion when even an attempt was made in an extensive way to in-

troduce sheep was during the drought of the sixties. The experiment was disastrous, resulting in the death of the sheep. The sheep men, who go into the reserve, rely on the brush for feed. This they fire, on retiring, for the new growth in the Spring. In the Spanish and Mexican times, the back Sierra Madre ranges were used in a small way by horse thieves. Some old Indians and half-breeds informed me about twenty years ago that these distinguished gentry had a great deal of trouble with bears eating their stock. Later along, other horse owners going in from the Soledad pastured for years an average of fifty head of horses in the forests. To improve the feed they burnt the brush on the back ranges for a number of years quite extensively. The water-sheds most affected were those of the Soledad, Tejunga and San Gabriel. This went on until the heavy rainfall of 1884. The result of this was the destruction by torrential action of a widespread character along these water courses. The damage in the lower reaches of the San Gabriel was tremendous. The Tejunga floods swept away roads and bridges and destroyed a great deal of land and washed away a considerable number of houses in the city of Los Angeles, of which latter event I was an eye witness. The Soledad canyon became over and over again a raging torrent. Damage commenced by tearing out bridges, which were repaired or replaced only to be swept away again by the next rain. Finally the entire Southern Pacific road-bed and bridges in this canyon were utterly destroyed. Railroad travel was suspended for six weeks. The railroad was rebuilt at a higher level as the only means of safety. When we consider that this railroad had before these repeated and extensive mountain forest fires remained uninjured, though heavy rainfall years had recurred from time to time, we are justified in blaming the horse owners and their fires for damages that ran into the millions. If the Southern Pacific had paid ten thousand dollars a piece for the 50 head of scrub horses that occasioned this devastation and had thereby kept the mountain covering intact, the $500,000 involved wuold have been a cheap escape from the loss of property and business they suffered from. Since that time until last year, there has been almost no pasturage attempted in the Sierra Madre.

A review of the Southern California reserves shows us that the pasture interests in the mountain forests is so absolutely small as to be a negligible quantity in any scheme of forest management. When considered in comparison with the vast interests at stake in the preservation of our mountain water-sheds, the pasture interest sinks into

an infinity of nothingness. It is clear that absolute prohibition of pasture on the public lands of the forest reserves of Southern California is the only rule to make. We have left the private holdings within the reserve lines. In these private holdings, I do not include those of water or power companies or of resorts. This is because these help and do not injure the forests. In the Pine Mountain reserve, the private holdings are nearly all confined to the springs and available water lands. These are said to be all held or controlled by one man. This gentleman informed me recently that he was considering the fencing in of all these springs and the use of the forests for sheep. While sheep can go without water for consiuerable periods, when the feed is green, they cannot do this during the dry season. Consequently these spring holdings with the reservation open, would mean a pasture monopoly to the controller of the water. This is a scheme of control that has been availed of elsewhere in the semi-arid districts to secure pasture monopoly. Its rank unfairness to the public interest and general taxpayers is apparent. The only other reserves with extensive private holdings are the San Jacinto and the San Bernardino. The patrol can restrict the pasture to such private holdings, but it is a most difficult thing to do.

CHAPTER X.

DAMAGE TO FOREST LANDS FROM SHEEP.

To return to our sheep, we note that the excess of damage to the forests due to these animals over all others that enter our forests in serious number is in the following points:

1st. Close group feeding and general close order habit of resting, traveling and eating.

2nd. Sharp, hard feet that cut and pack. By this means both young trees and grasses are destroyed; the land does not take the water and permanent damage is done by off wash of immediate surface, lack of rain penetration with consequent dryness of slope and of course increased detritus and flood damage by streams draining districts affected.

3rd. The close grazing of the individual sheep. Sheep eat seeds, bite out grass roots, feed on brush and either tread down, bite off or eat young forest trees when other food growth is scarce. Sheep may follow horses or cattle and find something to live on. To follow sheep is to find nothing. No grazing animal can live with them. Neither domestic nor wild animals can find a living after sheep. Sheep pasture in the Sierra Nevada exterminates game and forces the prospector traveler or forest officer to carry feed even for his burro. No one knows what desolation can invade a country until he sees it after the ravages of sheep.

4th. Fire setting by the herder. Parties reporting on this question say that the sheep-herder in the public forest makes from two to four fires a day for personal reasons. The herder rarely puts out such fires. It is also a common practice with sheep men when leaving the mountains to set fire to improve the feed for the next year. Whenever sheep occupy the public forests in our dry summers there is always a haze or pall of smoke over the entire forest country which frequently extends to cover agricultural sections. When sheep are kept

out of the public forests as for several years was done by the U. S. cavalry patrol in the Yosemite National Park, the feed recovers and the smoke nuisance is mitigated. Even the several incendiary fires set in this Yosemite reservation and due to the hostility of local residents or occupants to the military, had only a temporay effect in renewing smoke in the air in that quarter. The claims of the sheep men and the public forest pasture question will again be discussed. We can say now that whatever opinion may prevail as to the Oregon forests or upon the pasture question in the northern part of California, Southern California conditions admit of but one opinion. This is against any sheep grazing in the public forest reservations. The sheep industry is now very small in this section of California. Higher uses of land have constantly and for years been driving sheep out of Southern California. We can do better with the land than to keep our valleys great plains of brown dust with far separated herds of sheep followed by howling coyotes and carrion feeding buzzards. We can do better with our men than to force them into a life of solitude; into the life of the sheep-herder, where the family is impossible, manhood debased and where for months the herder sees no human being. In early times on the large sheep ranges here the herders' supplies were taken around once or twice a month and left at the night corral. The herder was always away at that time. It is no wonder that these sheep-herders thus so much isolated from humanity produced by far the largest proportion of insane of any class in California. The effect of the herder's life was mentally the same as that of solitary confinement.

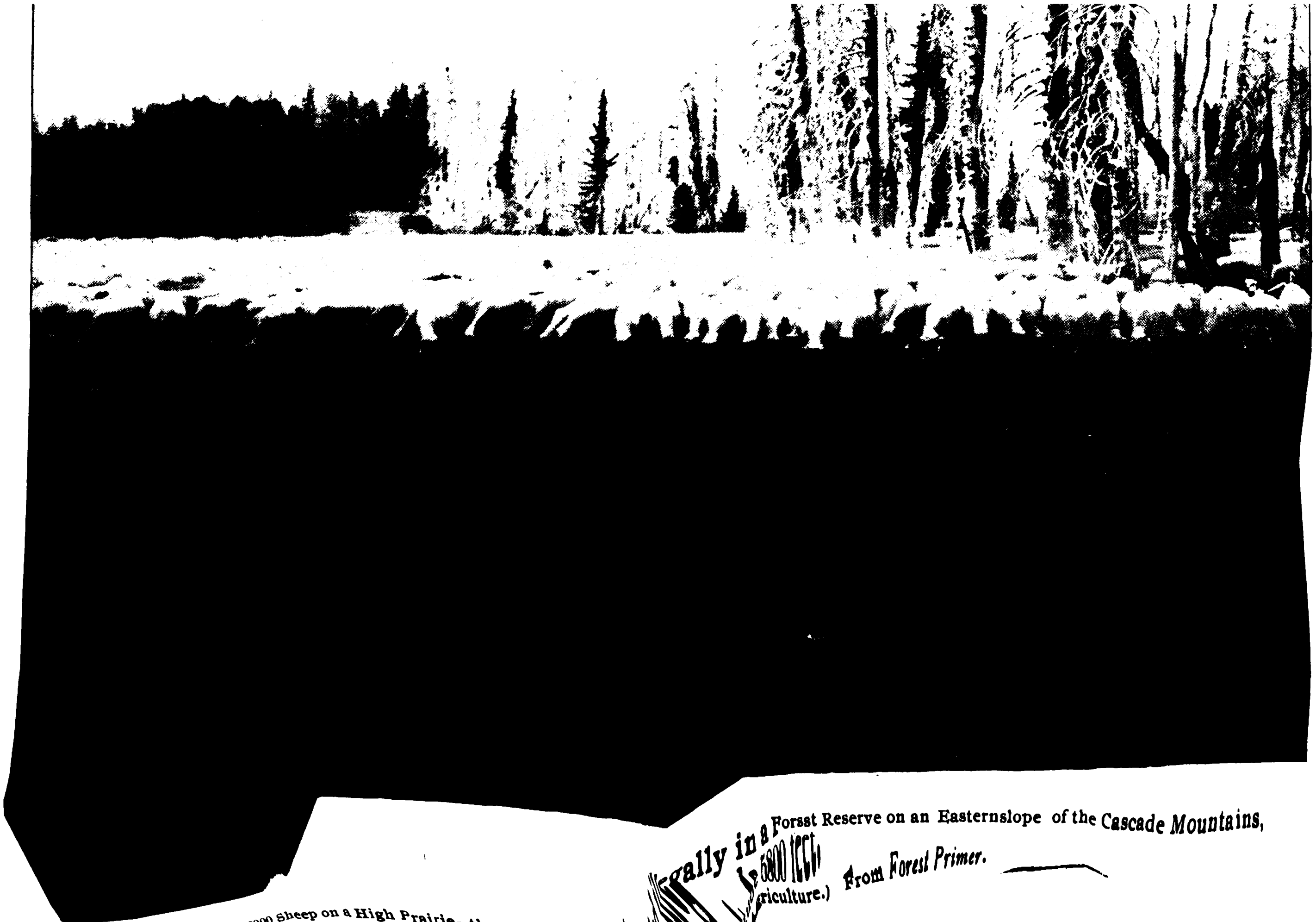
There is no record known to me in the world of sheep pasturage on public or communal lands but what shows the following results:

A. Diminished value to the point often of final destruction of the pasture for sheep. The outcome of sheep pasture on public or communal lands is in the end reduced to no pasturage for sheep. That has been the history everywhere. The most recent instances are Greece and Asia Minor, South France and Spain. France and Germany have substantially brought this under government control. In Southern California even the private pastures under sheep have diminished in sheep-carrying capacity.

B. Final and absolute extermination of public forests thus used by sheep. This includes trees, brush and everything.

C. Diminished water holding power of such water-sheds.

D. Flood and torrent destruction to valleys and lowlands.



A Flock of about 2000 Sheep on a High Prairie—these sheep being herd[illegible]gally in a Forsst Reserve on an Easternslope of the Cascade Mountains, Wasco Co., Oregon. A[illegible] 5800 feet [illegible] Gifford Pinchot, Forest[illegible] [illegible]riculture.) From Forest Primer.

E. Consequent progressive diminution of agricultural output.

F. Diminution of population.

G. Finally the desert.

With such results as these is there any community that can afford to allow the misuse and abuse of its public forest lands for sheep? Can any community be so indifferent to its interests or so insane as to sign its own death warrant?

CHAPTER XI.

GOVERNMENT CONTROL REQUIRED TO ABATE EVILS

The only true and permanent solution of the question of pasture or settlement of private holdings within forest reservations is expropriation of them by the government. This is what we must work for. Expropriation of private holdings in the forest reserves is a comparatively small question in Southern California. It is a large question in the Sierra Nevadas. A person has, under our present laws, a right to use land to which he has title wherever it may be. Access to it is a part of the right of use. The only limit to this right is that its exercise shall not damage others. In the forests such a damage from pasturage could reasonably be considered to have four forms:

1st.—Destruction to others and to the public lands by fire spreading out of private lands.

2nd.—The pollution of springs and streams.

3rd.—The damage by diminished water supply.

4th.—The damage incurred from increased torrent action.

The practical question is who would bring the injunction suits to prevent injury, or damage suits to pay for injuries done. The choice lies between the Attorney-General or organized societies. It must be assumed also that the courts would take some time in accepting and applying efficiently this doctrine. It has been so applied in Switzerland, but with the aid of very severe laws against the use of private or communal forest lands in such way as to threaten the community with injury. The shortest and safest road for us is expropriation of private holdings. We can, however, use and continuously use the other more tedious legal remedy for immediate protection against greed and injustice.

Along the fringe of civilization, there is always a tendency to revert to primitive types of life and to primitive types of government and property holdings. Primitive man was everywhere and is everywhere more or less of a socialist. It may be more strictly accurate to say a communist. Most property and all land is held in common in primitive communities. The legal doctrine of "ferae naturae" is a survival

of this common ownership theory. Property in primitive life is confined to possessions in hand; so it is yet with wild things. These are still incapable of private ownership and may be taken wherever found. This is with us limited by the doctrine of trespass. You may raise a trout from the egg, but the taker from a boat or public place, or from any neutral ground, is the owner. This is not so with a cow or horse. The use in common of our public forests is another survival of primitive socialism. The results of this system are at first not unfavorable to the general public.

With increasing wealth, it becomes more and more unfair in its operation. Besides this, the pasture is of less value than the timber, which its use threatens. It is of less value than the water supply. It is of less value than the valley lands threatened by the torrents forest pasturing finally creates. And the end of it all is the extinction of the mountain pasture itself, as in France, Spain, North Africa and Asia Minor. Thus common pasture in forests destroys far greater values and finally destroys the pasture.

In a general way experience uniformly and everywhere is against pasture in the forests for the highest and best interest of the community. Our unregulated pasturage in public mountain forests is unfair, injurious and immoral. It should be everywhere ended. In the Sierra Nevada there is a condition which justifies investigation with a view to determining whether there is not a district in which regulated pasturage, with payment to the public for such use, could be permitted without an injury greater than its returns.

In that range there is an alpine district containing extensive natural pastures. They are often above the timber belt and nearly all above any commercial timber. It is worthy of careful examination to learn whether a limited amount of stock only allowed to enter at the season when the grasses can seed themselves and hold their own is not compatible with the safety of the forests and of the water-sheds.

Sheep probably derive the most benefit by summering in the mountains, both as to their health and their wool product. These animals, however, are the ones that do the greatest damage to the forests and water-sheds. Sheep herders are also the class that do the most damage by fire. They are, in fact, the most difficult men to deal with we find in the mountains. Force alone controls them. Pasturage in forests is a delicate question to deal with and can best be dealt with by restricted experiments with careful water measurements, study of water delivery and forest examination before and after pasturage.

In Australia large districts have been leased to sheep men there known as squatters. This policy has probably greatly retarded the growth of that community. These sheep ranges are generally in more or less forested districts, called "the bush." In a great many of these ranges, the forest trees still stand, but entirely dead. The death of these mature trees in Australia has been due to the sheep men's practice of ringing—a practice common in our own early growth. But in our case, it was to permit small farms, while there it permits vast lease-holds with a sparse and unsettled population.

Australia has been suffering severely for four years from drought. Whether this drought suffering has any connection with the sheep use of forest lands, I cannot say, but the drought has been coincident with extensive forest destruction. The intelligent forest officers in Australia have more power than we have given to any one in forest matters, but they have been unable to deal with the squatter sheep interests at all. They recognize the injury it is doing to their forests and water-sheds. The principal sources of injury both to mountain pastures and water-sheds is premature and excessive pasturage. Under our present lack of system this cannot be controlled. Even wild animals, when kept in excessive numbers upon a range, injure or destroy the forests and the pasture. Several instances of this are mentioned by Marsh.

A striking illustration of the effects of excessive pasture by wild animals exists in Golden Gate Park, San Francisco. Considerable portions of this park have been reclaimed from sand dunes. In a part of this reclaimed district, a large area was fenced in for deer and other wild animals. The number of animals grew and the end of the resulting over-pasturage has been the destruction of all the grass and shrubs and the death of nearly all the trees. This corral is now as bare and sandy as the worst of the dunes. It is in great contrast to the surrounding park. Of browsing domestic animals, the camel does most forest injury, the goat next and then the sheep.

Southern California is fortunate in having no vested right to do a wrong fixed upon her mountain water-sheds.

We can prohibit pasture in the forest reserves without stepping on too many big men's toes.

All we require for the safety of our mountain forests and for the safety of our mountain water-sheds, is an intelligent scheme of management for the forests; an intelligent body of men to carry the scheme out and a forceful leader to see that they do it.

CHAPTER XII.

THE FOREST PROBLEM IN THE WEST.

The economic interest of the American people in their forests everywhere, and especially in the West, is to preserve the integrity and water holding power of the mountain watersheds of the country. This is clearly the public interest, whether these mountain watersheds could or could not support by their products and wise use a system of management guaranteeing the integrity of their water-holding power. The public interest is both economic and humanitarian in preserving the mountain forest covering. Without forest preservation, most of our remaining wild public land districts cannot be settled, and districts already settled are likely to lose in man-sustaining power. This has occurred already over wide areas of the world from undue forest denudation, on the one side by the irregular or exhausted water supply, and on the other by the destructive action of flood and torrent through sudden rainfall delivery from bared areas. The proper preservation of forest balance does not require that ripe timber should not be cut, or that other uses, such as mining, should not be enjoyed.

The interests and requirements of districts vary in what treatment of forested areas is most advantageous. In most of the West, and in all of the Southwest, the conditions of topography, rainfall and climate exact the highest care and treatment of the comparatively small forested area, all of which in the Southwest is on mountains or high plateaus only.

JUDICIOUS USE OF FOREST PRODUCTS ADMISSIBLE.

In this district it were better for the country and for its people that no use should be made of forest lands or forest products than to have the forests wasted and burned, as at present is generally being done.

However, no such drastic remedy as the isolation of the forests

from human use is necessary. Under a proper and intelligent forest system, the integrity of the watersheds can be safely maintained, and yet plenty of use can be found for both land and products; uses that can go on without fatal results to the forested area.

It is only in the extreme Southwestern mountains that the conditions are such as to counter-indicate the cutting of any timber, or even fire-wood, in the mountains. But even there mining, resorts, power companies, and irrigation works can be established with no disadvantage to the trees or chaparral, but rather to their increased safety. The nation can gain by preserving its forests in safe proportion, and can in no way consent to see this proportion of safety to its people diminished. The nation will gain by forest preservation, even though the system be without any resources or power of self-sustenance.

While forestry has become a living issue in the Atlantic States, through the depletion of perennial flow of springs and streams and increased flood action, and probably by greater and increasingly injurious extremes of frost and heat arising from forest destruction, in the West and Southwest effective forestry is a question of life or death.

With irrigated districts, present or prospective, the conservation of the Forest Natural Reservoirs is at least as important as the conservation of any part of the rainfall by artificial storage, diversion or distributing systems.

FEDERAL MANAGEMENT REQUIRED.

The lands on the mountains and watersheds in this part of the United States are in large part Federal public lands. By the extensive reservation of forested mountain lands from sale or settlement, the Federal government has committed itself to a rational forest system. What the situation demands, and what the people desire, is a forest management of these important mountain watersheds that will serve the highest interests of the entire community. Interests built up under the neglects and waste and abuses of the government's forestal mistakes and laches should be treated with all the consideration the safety of the communities affected and the welfare of the great majority of the people permit.

All foresters, and especially all foresters in the Southwest, endorse and must endorse a Federal forestry policy, whether the forest management pays its way or not.

The government forestry systems of European nations, of Canada,

Algiers, India and Australia, are self-sustaining, and for the most part bring in considerable revenues. Curiously enough, it is in the countries like Spain, Arabia, Persia and Turkey, in which forestry is neglected, where national productive power has most diminished, and in which both nation and people individually are poorest.

The success of other countries in maintaining national forest systems invites our attention to this subject.

The principal revenue from all forestry systems is from the sale of forest products. These are mainly merchantable timber and fuel. The Western districts, in which the principal areas of public lands exist, are situated so that one part or another of California would resemble their conditions closely enough for preliminary plans and outlines of forest management appropriate for the entire Western public land area.

California contains mountains and plains, valleys, farm lands and deserts. In the Northwest, its climate is one of, if not the moistest in the United States; in the Southeast, it is one of the most arid. In the Redwood belt there is a very large rainfall, and almost continuous fog and mist between the rain seasons. In the Cocopah desert years pass without a drop of rain, or even a cloudy day.

California conditions, carefully considered, can do much to outline a forest and public land policy for the entire West.

What is the public land situation here?

California contains 99,361,083 acres of land; of this land, the area appropriated is 40,392,418 acres; the area unappropriated is 43,841,044 acres; the area reserved is 15,127,621 acres.

This gives a substantially accurate picture of our land situation. In other states, including and west of the Rocky mountains, the public lands are in much larger proportion.

The above figures, however, do not give the exact facts. Of the appropriated area, some has gone to the State for taxes. In some of the mountain counties this tax area is quite considerable. The State Controller and the county officers thus far have found no general record of this tax land; therefore no one can tell what it amounts to.

Of the area reserved, a considerable part is patented and in private hands. In some reserved districts the proportion of private holdings is large, in others very small.

The National Yosemite Park, of about one million acres area, is a little more than half in private hands. The San Gabriel Reserve, from the Cajon west, has a very small proportionate area in private

hands, while the San Bernardino part of the forest reserves of the South has a considerable area in private hands.

The reserve system suggests the policy of Switzerland. In that republic experience has demonstrated the immediate and often awful results to lower agricultural lands from forest denudation on steep, high mountains.

From this experience has been evolved a forest system which lays out as a part of its functions forest reserve districts. The lands within these, whether public or private, are under public control, and not a tree can be cut without public authority. We may come to this system some day.

There are in this State about eighty-three thousand square miles of public lands in the hands of the Federal government. An examination made by expert civil engineers on section lines, and mapped by the old State Board of Forestry, in its reports, shows that the mountain land with merchantable timber is substantially all in private hands. There is, generally speaking, little or no timber of merchantable quality and accessibility in California not in private hands.

Fuel and small wood costs more to haul out of the high Sierras at present than it will bring. There are restricted districts where the waste and fallen wood, or small standing timber, could pay its way for use as ties, posts, fuel or mining, but no large revenue is in sight from this source at present. Consequently, the sources of revenue and support of foreign systems is in a great degree absent in California.

We may assume that the known condition of California in this respect in one or another of its districts applies to those of the entire West.

There is, however, a source of revenue to the government from a rational management of its mountain forest lands, when handled in conjunction with the development by public irrigation works of the vast area of arid public land.

The reason why there is such a large amount of public land in California, and in the West generally, is that the land is all in an arid climate, and that it is therefore incapable of supporting a farmer or settler, without a secure supply of water for irrigation and often for domestic use.

The mountain forested areas are all incapable of agriculture in the Southwest. There is consequently no gain of productive area, as in the settlement of Ohio, for instance, by denuding them. On the other hand, these forests are the natural reservoirs of the Southwest.

The forests in this section are of the highest importance both to the irrigation districts already developed and also to the enormous areas that may by future irrigation works be made fertile.

Storage reservoirs, diversion works, ditches, etc., are all safer and more permanent when under a forested watershed than when under a bare one. In the first case, with forest covering, there is a minimum of flood action, and practically no torrential detritus to fill up the works. From a denuded watershed, the water delivery is irregular, torrential and detritus laden.

The public land now at its limits or near its limits of support of population can, by judicious irrigation works, be made capable of supporting a population of between fifty and one hundred millions. Irrigated land has always been that capable of supporting the densest population from agricultural returns. We see this in the history of the Euphrates and the Nile. In both of these cases, and in the more modern developments in India, we see that the important works were carried out by the community or government, were managed by the community, are thus managed, and that new work for further development in the application of water to land in genial and dry climates, such as those of India and Egypt, is planned or being executed solely as government undertakings.

There are three good reasons with us for this policy. The first is that the lands susceptible of improvement are largely public lands. The second is that the undertakings are too large for most private initiative, and the third is that a public administration of irrigated lands is the only one in which the land occupants can feel safe in not becoming serfs of the water company, as is now practically the case in the rich irrigated valley of the Po, where the returns are large, but the people in misery.

Governments in the past and governments now recognize the advantage and propriety of making their lands productive by public irrigation works. The peoples who have done this in the past have been amongst the greatest. One of the most powerful governments of the present day, that of Great Britain, is now, as it long has been, engaged in such irrigation development. The dam on the River Nile, near Assouan, will be the greatest land reclamation works in the world. The values created by the application of water to land in Egypt will far exceed the values created by the exclusion of water from land in Holland. Both are government undertakings. In our country the

government has undertaken land reclamation by excluding water, as by the Mississippi dykes. It has also added to land values and product values by the construction of harbors and canals, thus reducing or removing freight tariffs or lighterage and landing tariffs. The states on, or having, rivers have been benefited by this policy. So also the Coast States, or those on the Lakes, or served by the great Saulte St. Marie Canal have been benefited; so has the country generally been benefited. It is eminently proper that the people's government should apply this policy to the development of the rich and sunny Western lands that cannot produce and serve mankind without water. In this case, the benefit is direct to the public. It is the public land that will be most benefited. Homes for the people will be created. It is of course markets and a population of high productive power in our own bounds that we thus create. It is the conservative agriculturist that we thus introduce and encourage to balance the more radical bodies of employees in the great manufacturing districts Fifty million such Americans will consume more American products and support more American trade than all our present foreign trade combined.

RECAPITULATION.

Taking the public land area as a whole, we find some that is inherently worthless, some that can be made good and productive some where forests and their products can be safely used under reasonable regulations, some where the forests can only be safeguarded but not used, as in the chaparral mountains of the South, and a wide district that is at present used for pasturage. This pasturage of the public lands is unregulated. The pasture use is premature and excessive. The pastures thus constantly deteriorate and carry less stock. The public land pastures have deteriorated and are deteriorating in stock and sheep carrying power. Fighting and disorder is everywhere present amongst the pasture users. Sometimes they have wars. These stock and sheep men, as far as seen, welcomed a proposed system of leasing the public lands appropriate to pasture, under judicious restriction as to number of stock permitted on each section and the time of year when the stock should go on. The public lands in California have a present value for pasturage that varies with seasons It is estimated to have an annual rental value of not less than $250,000, and may exceed half a million dollars. Its rental value varies with the seasonal rainfall. The stock men would be glad to pay rent

and thus know upon what feed they could rely, without the present accompaniments of murder and arson.

Those districts where pasturage injures the watersheds could have the stock reduced to a safe number by reasonable regulation, or entirely removed. When we consider the vital importance of the entire forest question, and past and present precedent in the matter of forestry and irrigation; when we consider the effect of forest denudation in filling up navigable rivers and harbors, the importance of water to miners. to cities and to irrigators; when we further reflect on the empire at our hand and in our borders to be created by irrigation works, we can agree that forests, reservoirs and public land management all go hand in hand.

There is considerable timber in the San Bernardino and San Jacinto ranges that might be used for lumber if prices increase. The timber areas, however, are small compared to other Pacific Coast districts. They are difficult of access. In addition to these drawbacks the forests are open and the timber is therefore more knotty and less clear than that from the North. For these reasons no important lumbering has been done in our mountains for a long time. Reduction in transportation rates by railroad extension and harbor improvements have removed the profit from local lumbering. Lumbering is recommencing in the South because of higher prices. There is also very little pasture in the mountains. The most of this being in the Pine Mountain Reserve. The little pasture that exists is only practically accessible by long detour and entry to the mountains from the less abrupt approaches on the desert. Horses and cattle do comparatively small injury to the forests while in these pastures. Under judicious regulation it is reasonable to believe that the natural mountain meadows and high alpine pastures could be used by stock without appreciable injury to the water-sheds. The trouble with this use of the forest now is principally excessive pasture and lack of any regulation. From these causes grow the constant fights, arson and murder in our mountains between stockman and stockman and between sheepman and sheepman and between stockmen and sheepmen. Feuds, fires and assassinations curse our entire western mountain area of public lands used without lease, tax or charge by pasture men. Leaving out the questions of the value and conservative effects of forests, of lumber, mining, water storage and preservation of water-sheds which all demand a rational management of the forests, humanity alone demands a reform in the conduct of the public lands in forests. Present conditions in our

western forests give a premium to violence and invite to crime. The forests are important resources of the entire people. The integrity of mountain forest areas must be maintained in the interest of the body of the people. The Nation's strength demands it. Yet here insensibly has come upon us in our western mountains an unmoral condition.

In some places in these semi-arid districts a man will enter and purchase the few springs over an immense area of territory and fence them in. In this way control is obtained over empires of land by the purchase of a few quarter sections. In all pasture land cases the nation is never paid for more than a fraction of the land used. Generally none is paid for. Taxes to support both the nation and local community are evaded. The herders pay no land tax and rarely any other tax and in addition to all these shortcomings, their usual operations, their carelessness and their vendettas, so often accompanied by setting fire to each other's ranges, all go to destroy the capital and productive power of the community. It is the sheepmen with whom the forester has the greatest quarrel. All over pasture of any district deteriorates the value of the pasture. When these pastures are in forests or brush lands the injury to the pasture by over stocking sinks into utter insignificance compared to the injury of the forests and the injury of the water-sheds. Such injuries to water-sheds in the south of Europe, in Africa and in Asia have ruined rich districts, depopulated towns and destroyed nations. In no case of these fatal consequences coming from forest destruction on hill and mountain water-sheds is there an instance of topography and climate indicating more danger from such action than in Southern California. Whatever damage and cost has come elsewhere from a neglect of water-sheds we in Southern California must anticipate greater damage and cost. In fact, we have no reason to expect anything short of eventual annihilation in case we go on burning and wasting and baring our steep mountain water-sheds.

The public land system as a unit can be self-supporting and revenue producing. All interests can be fairly dealt with, and the country brought to its highest productive power.

Those who engage in promoting this great work have strenuous efforts before them; They deserve the garlands of reward as civic patriots as much or more than those who foment distant foreign wars. The conquest of this empire within our bounds for our own children is more useful, more profitable, more secure and more glorious than any foreign conquest can ever be.

CHAPTER XIII.

FORESTS IN RELATION TO TORRENTS.

A torrent is an intermittent stream. At times, a torrent is a considerable body of rushing water loaded with detritus. At other times, its valley course is a broad belt of boulders or sand, with a thread of water, or no water at all.

A torrent is always a destroyer. It is never beneficial. The term is not applicable to rivers, even though these have distinct flood periods, and carry large amounts of detritus, like the Nile, or our own Sacramento and San Joaquin rivers.

A torrent cannot originate on level land. Man's use of level lands, however, generally increases the volume of torrents.

ORIGIN OF TORRENTS.

A torrent is caused by rainfall on a broken or steep watershed in such conditon as to be unable to detain and prolong the delivery of the rain. There is no record of a torrent arising from a well-wooded water-shed. A forested water-shed cannot have torrents. This is a fact which the student and the political economist should always bear in mind. To the extent that a water-shed is without forest covering will be the possibility of torrents arising from it. So also will be the destructive power of these. A bare mountain water-shed with any rainfall must produce torrents. The steeper and more extensive the bare mountains are, the more dangerous and destructive will be the torrents arising from them. These points are not guesses. They are facts. They are not matters of theory. They are demonstrated without a single break or a single exception.

Complete denudation of a mountain water-shed means, with absolute certainty, the creation of torrent action. We do not have to suppose that this will be the result of mountain denudation. We cannot think that it only may be the result. We know that torrents will result from the destruction of forests on mountain water-sheds.

The situation as to torrent extension and creation in Southern California invites our attention. More than this, it demands action. This need grows out of three things:

1st.—Our topography. We have here a series of Sierras. These

are steep, high and extensive. They are almost without foothills. They rise directly out of the vegas and irrigated valleys that mainly depend on the water delivery from them for life.

2nd.—We have a climate that has a prolonged dry season of sunshine. This is alternated with a season of possible rainfall that is occasionally almost as dry as the summer. From time to time there is a diluvial summer rain on the eastern part of the Sierra. One of these rains produced torrent action that did a considerable amount of damage in passing through the City of Redlands. In a decade, there always have been one or more seasons of very heavy rainfall during the period of expected rains. The rainfall increases with the elevation to at least four thousand feet. It is therefore greater in the Sierras than in the valleys.

During the season of '84, the rainfall in Los Angeles was 38 inches, most of which fell in a period of six consecutive weeks. At the same time, the rainfall on the Kinneloa ranch, at the foot of the Sierra Madre range was 60 inches. This illustrates the difference of rainfall between mountain and valley. A notable fact in this connection, shown by twenty years' observation on this ranch, compared to the observation at Los Angeles is that the greater the rainfall the greater is the excess precipitated on the mountains.

3rd.—The rainfall in Southern California is so near the limit of a possible support of mountain tree and brush vegetation that forest destruction, and consequent injury to the water supply and increase of torrent action, is unusually difficult to correct and demands prevention.

A recent examination of the Guadalasqua, Siques, Malibu and Garbattan districts in the Santa Monica Sierra illustrates this. This Sierra is neither so high nor so steep as the great main ranges. The covering is almost exclusively chaparral. It has long been exploited by wood-choppers and cattle and sheep men. Its stock carrying capacity is small and is constantly diminishing. To eke the feed out, the customary methods have been adopted on both private and public lands. Fire is set in the chaparral in the fall, so that the stock can have the new shoots from the roots to feed on the next season. This operation followed two or three times kills the brush. The rains then carry off the soil, and there is neither grass nor brush nor feed of any kind. A report just made to me on these districts shows that there are extensive areas where the native growth is destroyed and the mountains bare. Springs never known to be dry by the oldest American and Spanish set-

tlers, are now entirely gone. The supply of drinking water has for the first time become a vital question. This situation is going to be difficult to improve. If done, it will be quite costly—in fact, it will probably cost more to reclaim than the district is worth.

Several cases of what appears to be permanent destruction of forests exist on the eastern edge of our reserves. One of the most accessible of these is on the southeastern flank of the San Bernardino range, fronting on the San Gorgonio Pass. This forest was still standing, when I last saw it, twelve years ago. Fire had killed it many years before. The trees stood white and stark, where they had burned to death. The soil must have been burned up at the same time, or else had been washed away. There was not any. The dead forest had neither grass, flower, bush, or living thing in it. A torrent-wrecked canyon debouched below it off to the desert where it has repeatedly washed out the railroad. The desert is at our door today. It is pushing up against the mountain barrier that divides us. It is creeping up on the passes, north and east and conquering a corner now here, now there and even has footings on and inside our mountain wall. The deserts even now come into our lovely valleys for a few days with their fire and furnace breath to look at the rich booty they may some day hold. The armies of the forest, steadfast and true to their posts, are our allies. It is the forest that mans the rampart between our orchards, fields, flowers and cities and the frost and fire of the glittering wastes of the deserts of death. What shall we do with these forests? Shall we destroy our own friends and protectors? The fact is that this is just what we are doing. Greed, ignorance and crime dominate and destroy our forests. We stand by and fiddle, while the forests burn.

Along the Sierra Madre, the fire scars are becoming more and more numerous. They are growing larger and larger. All this is in plain sight from a steam-sped car window. Back in the range, it is a hundred times worse. What the next heavy rainfall season will do in torrent action is a serious quetion.

In level or nearly level lands, within settled districts, the rainfall off-flow becomes more and more concentrated. Ditches for roads and railroads bring the off-flow together and increase the cutting action of the running water. As the land is more rolling and gullies or incipient torrents commence, the land owners block them here and divert them there, and so create considerable torrents within cultivated districts. A striking instance of this is the torrent created by cleaning off low brush and concentrating small washes, at Altadena.

This place used to be called Las Flores because the old sailors could see the masses of golden poppies on that mesa clear from San Pedro roadstead. I knew the mesa and the entire plain below it well, before settlement. There was no barranca there, when I came early in 1880. There was no wash, no torrent and no sign of any across the plain below Las Flores. Then came settlement and clearing. The first heavy rainfall, after the clearing, started the Monks Hill barranca and carried a newly created torrent out over the valley. That was in 1884. Every heavy rainfall since has increased its force and destructiveness. Orchards, farms and gardens have been cut through and destroyed. Bridges to the number of eight have had to be constructed just for barrancas and cuts and temporary torrent flow.

The Monks Hill barranca is twenty-three feet deep in one place. The torrent now extends for miles in uncertain and destructive course. This is a place very easily visited. It is just east of Pasadena, and all the east and west roads cross it. Then there are still the old settlers like Barney Williams, Charles Bell, P. M. Green, T. P. Lukens, and a number of others who remember the time when there was no barranca and no torrent. All along the foothills or mesa, one will find the evidence of increasing torrent action. There are several forcible illustrations of this action just east of the one just cited.

CONDITIONS OF OFF-FLOW.

The effect of plowing or cultivation on off-flow seems to vary with soils and grades. On level land, it probably increases the water-holding power of the land. On hilly land, this effect is doubtful. At Kinneloa there is an apricot orchard on a hillside, with a grade of one in eight and a half feet. It was planted twenty years ago. The orchard has always been prepared by grade furroughs for the rainy season and no distinct wash has occurred. A piece of land by its side and with the same grade was not cleared and has remained in chaparral. There is today a difference of two feet between the cultivated and the brush land. Two feet of the orchard surface is gone. The soil in the brush is soft and spongy with the humus. Water does not run on it, steep as it is. The orchard soil is hard, bakes easily and takes water with slowness and difficulty. A sharp rain will start little rills in the grade furrows.

Another interesting thing that has been demonstrated on this ranch, which was originally covered with chaparral, is the fact that when it

 ——* Barranca, a deep large gully.

was first cleared, it required irrigation much less frequently than later for annual crops, such as vegetables. Progressively with the years, the land took in the irrigation water more slowly and the evaporation from the soil was more and more rapid. The reason for this is that at first the soil was well filled with humus, which the sun and air gradually burned out. In a small way and on parts of the ranch water run in a very small stream on the ground will go furthest at first. The soil deprived of humus seems to have to learn to take the water. Thus you can take a little rill of water on hard ground for say fifty feet. As the ground takes the water and softens it, the ground takes more water, until your rill will end at thirty-five feet.

A somewhat contradictory case is that of the torrent bed of the Whitewater on the desert. This stream flows out of the San Bernardino mountains and takes its name from a sort of white clay it carries. Out in its boulder bed it deposits this clay and makes a water-tight channel, which extends the flow further and further out towards the desert. This goes on until there is a heavy rain and flood flow. This flow is short. It rolls the boulders about and breaks the clay bottom. As soon as the flood flow is over, the permanent water flow is found to be far back toward the mountain. This is the contrary of what we would expect. It then goes back to zanja building and so again extends its flow desertward.

In the usual experience of irrigation, the longer the time of flow, the further the water goes to its limit.

This ranch experience of the value of humus in getting land to take and hold water, and its value in preventing on hill lands storm off-flow is being availed of by bringing in and dressing the land with humus-making manures or plowing in green crops. It is astonishing to observe the difference that a good dressing of stable manure will make in the water-taking capacity of clay land.

OBSERVATIONS AT THE KINNELOA RANCH.

The Kinneloa ranch has its main orchards on mesas one to two hundred feet above the general level on the three sides. The slope is from one in eight and one-half feet to one in twenty-two. Before the chaparral was cleared off, there was not a barranca, gully or wash on the mesas, nor on the steep slopes from the mesas to the lower lands. The question of the storm off-flow became important the second year after the clearing. In spite of all the care taken to guard against soil cutting by storm off-flow, several have occurred. One barranca and

quite a number of gullies have been made in the mesa sides by storm waters that before the clearing did no damage. Constant care is required to prevent serious results. Barn yard manure dressing, freely used, increases the absorbative water power of the land and diminishes the off-flow. In this, it approximates in its effects to the old humus. Two systems have been tried on the ranch to prevent the rain off-flow. The first of these was the basin system. Furrows were run on a water-grade and turned into each basin reached. In this way, no furrow ran over twenty-five feet before coming to a basin reservoir. The land, however, took less and less water, as the humus was burned out. At last, in a diluvial rain, delivering three and one-half inches in a short period, every basin was filled to the brim. Several broke, breaking others and doing some damage. It became apparent that there might be a rainfall that would smasn the whole ranch.

There were three other objections to this system:

1st.—That the basins would not be broken up. This interfered with team cultivation.

2nd.—They were costly on a side hill.

3rd.—Silt and clay were deposited in the basins. This reduced the absorbative power of the land and made the basins almost water tight. It also prevented proper soil ventilation. This soured the soil and produced sickness in the trees.

The present method is a continuation into the rainy season of the system of irrigation. Five furrows are always kept with the least grade water will flow on, between each row of trees. With this system, storm off-flow has lost its terror for the steepest cultivated side-hill.

At this ranch there was a small alfalfa field on the slope of from one in ten to one in twelve. A part of this field is still in alfalfa. On no occasion has the rainfall on this field ever flowed off it. More than this, storm furrows, bringing the rain off-flow from the cultivated orchards above it and terminating in the alfalfa leave their water divided and absorbed in the field. It is in fact a torrent extinguisher on a small scale. I have repeatedly tried the effect of grass on a flow of water. Turn a strong flow of water on a lawn. You will have no cut. The water delivered from a hose concentrated will be sub-divided, and if it flows off the grass at all, it will do so in a gentle and broadly diffused way. With a large lawn and a large enough flow of water to finally cross, you may have another valuable experience. The water will continue to flow from the lower part of the lawn for a long time.

If now you turn the same force of water on a cultivated field, and let it find its own outlet, at the same distance as in the grass, you will find the flow stop almost the minute you turn the water off. I have tried this in a number of cases. It is easy to try and it is a striking illustration of what a difference in water delivery there is between bare land and grass. I tried this experiment in a larger way on my ranch. There is there an orchard in the canyon. Storm water rushed through this, cutting in some places and depositing several feet of detritus in others. I had this storm water conducted out of a channel it was cutting and turned into a eucalyptus grove. The stream was immediately sub-divided; its load of sand was dropped in a miniature cone, the water was absorbed; the torrent rushing into this grove was extinguished. The water absorbing power of the Sierra Madre range, with its chaparral covering is almost incredible. Steep as the range is at my place, I have only once seen a rainfall delivery across the ranch in the wash of the three canyons. It is very rare that storm off-flow occurs in these canyons at all. The brush till last year had been without fire for probably over forty years. The springs have been celebrated for their volume and regularity. The rainfall was absorbed in the mountains almost entirely and slowly percolating to more open quartz ledges, flowed through these to the springs. All the quartz ledges are curiously and conveniently faced on the south and lower side with a water-proof dyke. Mr. Koebig, the distinguished engineer, who has made such a study of the San Gabriel water-shed, indicates what an enormous difference in the Sierras forests or no forests make in their water-holding power. Mr. Koebig states that this fearfully denuded water-shed has a storm off-flow of over 95 per cent. in some places, while it ought not to be over fifty. He speaks of his own observation of the increased storm off-flow from a canyon just burned. He also compares the reduced summer flow due to storm off-flow from this great and much-injured water-shed with the summer flow from the small water-shed of Lytle creek, which has been but slightly injured. Lytle creek, with less than a third the water-shed, has about the same summer flow as the San Gabriel. This Lytle creek is also far more reliable and steady. Neither has Lytle creek anything like the destructive torrent power of the San Gabriel.

An interesting illustration of the soil-holding power of humus can be observed in a forest and on a road in a forest. Where the ground is covered with humus, you will find no mud. The soil does not stick to your shoes. The road soil, if wet enough, will stick to

your shoes. The same thing may be observed by running water on a grass plat. There will never be any mud. It does not matter how much water is put on. The only effect is to make the soil more receptive and to render the sod soft and elastic. The same water on bare soil, hard or cultivated, wili make mud.

These experiences can be easily demonstrated, even within the limits of a city. They are all germane to forestry.

VALUE OF HUMUS.

No one observing these results can overlook the importance of humus in the soil. The forest makes and protects the humus. When the forest is burned so is much of the humus, and sometimes all of it. A burned over forest, whether the trees are destroyed or not, cannot be expected to take care of as much rainfall as an unburned one.

Torrent action may and does occur from fire, without the destruction of all the trees. The destruction of the humus alone will account for a large increase in storm off-flow, and a necessary diminution of the springs. There are a number of instances in France of torrents created by forest destruction and of their subsequent extinction by a renewed forest growth. I have seen quite a number of the charcteristic torrent cones at the outlet of mountain canyons to plains not now active, and the stream that made them again perennial.

TORRENT CONES.

The torrent cones have a very important influence upon the water supply in Southern California. These cones are composed mainly of boulders at the outlet of the canyons and the change of grade from the mountain to the valley. As you go out into the valley, the boulders become smaller and more and more mixed with gravel and sand. At the lower end of the torrent cones there is all sand. Far out at the end of our storm flows, we find silt and clay. Tremendous deposits of clay are found at present and former river outlets to the sea along the county coast.

The torrents grind the boulders into gravel, and the gravel into sand, dropping the load both with the diminished grade and the diminished water flow. The water flow diminishes with every foot it runs on the torrent cones and washes. Our storm off-flow is well-known to be entirely of mountain origin. It is not so well known that our entire summer supply is the rainfall of the mountains.

Névé in the Sierra Nevada

CHAPTER XIV.

SOURCES OF WATER SUPPLY.

Our water supply is of two distinct types:

First: That derived directly from springs or streams in the mountains. It is plain that this type of supply is due to a rainfall in the mountains. Where the water-sheds are forested, other things being equal, the supply is largest and most regular.

The rainfall by the aid of trees, brush and humus gets into the mountains. These mountains are porous and have a great absorbative power for water. The water percolates slowly through these rocks and broken quartz veins or fissures, until it reaches an open vein. Through this, it flows to a low point and appears as a spring. The mountains are a reservoir and require the forest to detain the rainfall long enough to allow it to get into the rocks and soil. Our canyons carry summer water only because they cut at the lowest places the water carrying strata. It is the water-shed of the strata and its size and condition that determines the summer flow of every spring and stream in the Southern Sierra.

The water-shed of the canyon carrying the stream is not the governing factor. In a climate like ours, with usually six to eight months without rain, and sometimes without rain of importance for a year or more, there can be no reliable surface flow to supply springs and streams.

A careful examination of our mountain springs and streams demonstrates the fact that all of them have their summer flow from cut strata. These sources are sometimes masked in cienegas or deposits of detritus and silt. I have demonstrated by experimental tunnels in three of my own canyons that these mountain cienegas in canyons are supplied by quartz ledges, cut by the canyon and not by a bed-rock flow in the canyon. There are canyons, where there is a bed-rock flow, but such flow also originates in an open vein above from the rock. In the high Sierras, there are places like Bear Valley, where from the extensive and comparatively level district, a good year would doubtless furnish a prolonged summer supply of not deep seepage water. This is never the case in our canyons.

Above the Clouds at Echo Mountain, Sierra Madre.

Below the Clouds at Echo Mountain. Taken same day and just below the Picture Above the Clouds. Eucalyptus Plantation next to the Mountain.

Second: The water from the tier of springs in the valley. This water is also and exclusively derived from rainfall in the mountains.

There are in our valley lands between the Sierra and the sea at least two distinct water-bearing districts. One of these is represented by the tier of springs and artesian wells running across the San Gabriel from the Santa Anita to the Marengo ranchos; a second water-bearing strata comes to the surface at Los Angeles and El Monte and a third in the low lands back of Ballona, Long Beach and Newport Landing.

The Santa Ana water-shed and its off-flow in that valley, has the same general feature. The waters from our artesian water belt and from such springs as those on the Santa Ana, San Gabriel and Los Angeles rivers are derived from subterannean lakes in which seepage water is upheld by strata impervious to water. Sometimes, this subterranean water is under pressure and between double lines of impervious strata, as in all of the artesian belts and sometimes it is not, as in most of the San Fernando and San Gabriel valleys.

This water comes from the winter rainfall in the Sierra, which coming out of the mountains into beds of boulders, gravel and long sand wash, sinks down into the soil and by slow percolation and large valley areas of storage, forms the reliable supply of our great second tier springs. These again, with surplus winter flow, store the wide lowland valleys with water available in summer.

THE RAINFALLS ON THE VALLEYS INSUFFICIENT.

The rainfall on the valleys themselves cannot furnish this water. The rainfall is inadequate to do it. There is a subterranean lake in each of our large valleys. These are very generally tapped by wells. We have generally learned what this water level is and can now calculate just what the depth of a well must be at any point to strike water. This is found by taking the known water level and calculating the higher or lower land surface level above it, where the well is to be dug. If we take these wells in the San Gabriel, above the line of springs toward the mountains, we will find that they run from forty to three hundred feet deep according to the land-level.

In digging these wells, we find the surface moisture to vary in depth with season and treatment of land. There is always dry soil at all seasons between this surface moisture and the water level. It is therefore clear that the rainfall on the valley and above this lake is not the source of its supply.

If you go out to the roaring mountain torrents flowing from the

Precipice Canyon, Irrigating Stream Sierra Madre.

mountains in heavy rains and note the waste winter water sinking in their boulders and gravels, you will see where the water does come from. It is only in extraordinary years that any of our torrents cross the valley and flow to the sea. The exception to this rule is the water delivery from denuded and burned off water-sheds. More of such rainfall storm-flow is lost.

The moisture on the San Gabriel valley lands this year from the rains in no case penetrated three feet. Eighteen inches is about the average penetration. It is very rare that the rainfall moistens more than ten feet down. The water level will average 150 feet in depth. San Fernando wells shows the same condition. Those deriving their water from these lower valley springs and dug or artesian wells derive it in fact from the rainfall on the mountains just as surely as do those whose pipe lines and ditches take the water directly in the mountains. Their interest in the preservation of the mountain water-sheds is equal to that of the mountain system owners. The damage from floods and torrents is as great in the valleys as near the mountains. The volume of flood water is undoubtedly less the further from the mountains you go.

This is one thing that makes the torrent more dangerous while it has any flow. It cannot carry its load of detritus as its volume decreases. This deposited in channels however, well defined in the start, must and does raise them constantly. It becomes difficult, costly and at last almost impossible to control torrents with water absorbing cones like ours and increasing detritus delivery from burned and denuded mountains. The worse the fires and forest destruction, the worse will be the floods. Besides this, the more damage there is to the mountain water-sheds, the more rapid will be the water delivery from them. This lack of percolating time for the rainfall to get into the mountain rock and soil will also result in a lack of percolating time to go through the cone and washsieves into our subterranean lakes.

Run one hundred millions of gallons of water from a mountain water-shed to its cone of boulders, gravel and sand, and the time of its delivery will govern what becomes of it. If this delivery is made in one hour, you will have a flood, most of the waters in which will pass by. If this delivery is over a period of ten days, no water will be wasted at all. It is not necessary to go any further into an argument or detail on this question in Southern California. We have seen the results of unwisdom in forest treatment. We know it from personal observation, and we fear for the future, unless our mountain water-sheds

are safe-guarded. Every one here is in favor of forest preservation or the mountains. In the matter of the water absorbing power of our torrent cones and washes, we can gain an idea of what such porous channels must do by taking the absorbative power of large rivers generally.

The Po, a great river of northern Italy, at its junction with the Ticino, has sometimes delivered 19,500 cubic yards per second. This is near its outlet from the mountains or in its upper course. At Ponte Lagoscuro, near Ferrara, pretty well down its course, the measurement has never exceeded 6,730 yards.

The Mississippi, below the mouth of the Ohio, has had a delivery of 52,000 cubic yards per second. This discharge at Baton Rouge, in spite of many important tributaries, was only 46,760 cubic yards. Marsh, who is my authority for this, states that the Rhone and other large rivers, are affected in the same way by absorption of water in their course.

Southern California everywhere shows how near it is to the line of torrent destructive action. Every stream here has a more or less torrential character. Every mountain canyon has its torrent cone now with the beds of boulders, gravel and sand extending valleywards. There is no true perennial stream from mountain to sea in this section.

One has only to take the government contour maps and observe the rise of grade at every canyon outlet due to the deposits of detritus by the streams' torrential action to see the importance of the torrent question. In fact, you do not have to leave Los Angeles City to note this character of action. The river bed has been raising itself and now flows on a sort of ridge between artificial dykes. A great deal of the elegant Southwestern section of the city is lower than the bottom of the river bed. In some places the river bed is over twenty feet above the level of the street grades.

A torrential stream, like the combination of the Tejunga and San Fernando torrents, that flows out through Los Angeles, is a dangerous thing. A lot of old rotten wooden dykes do not make it safe. In 1889 the river broke out of its channel and did a great deal of damage about Nadeau and on the Laguna. It flowed out that time to the East. If it took a break to the west, people would commence to take an interest in forestry in the city of Los Angeles.

Every year the water-holding power of the water-sheds, the offflow of which must go through Los Angeles, is diminishing. The city people have an idea that the Southern forests interest the irrigators

most. They think forestry a good thing, but that the immediate injuries of undue denudation would only fall on them secondarily through the lessened power of purchase of irrigators with less water and therefore with less crops. The truth is that no part of the community stands in more immediate and greater danger from forest destruction than does Los Angeles city.

1st.—In the loss of its permanent water supply by the flood delivery of the rainfall suddenly from the burned and bare mountains. every year getting worse, and

2nd.—Because it has a torrent bed running right through the city, which has already, by the deposit of detritus, elevated itself above the general level.

Some city people have never seen the Los Angeles river in its torrent form. If they do, they will at once realize what a menace it is to extensive sections.

All our streams gradually diminish in flow of water, as soon as they leave the mountains, or even before. Most of them do not really get clear of the mountains in their normal flow. It is only in flood or torrent time that they go far out toward the sea in a continuous surface flow. In the minor streams, you will often find, after rains, a roaring and unfordable stream close to the mountains and hardly anything a few miles out in the valley.

Torrents are only found where mountainous water-sheds are in part or wholly without adequate covering of forests. Forests with us always include chaparral. After a torrent has been created, the great question is how to deal with it, and how to diminish its destructive action. All of the methods that have been used in dealing with torrent action are also in use in dealing with floods in general.

First is extinction of the torrent. This can only be completely accomplished by reforestation of the denuded water-shed. Reforestation has occurred by the operations of nature. It has also been done by man. Nearly all of this artificial treatment is in France. The work of replanting denuded mountain water-sheds and the fixation of drifting sand dunes by forestation in the south of France is of the greatest interest and value to forest students in the West and especially in the Southwest. An expedition has been proposed by a number of Americans to make an early tour through the German forests. It would be worth every forest student's while to make the trip through intelligently and efficiently managed European forests. For us, however, the trip should be through the south of France and Algiers.

Native California Palms in a Sierra San Jacinto Canyon on the Colorado Desert side.

Spring in a Sierra Madre Canyon—Water for Irrigation.

Extinction of torrents by re-planting forests has been done. It is an expensive thing to do. However expensive it is, the ultimate cost is far less for any community than palliative measures in the valleys and plains.

Second—Dykes to keep the torrent waters within a defined channel is the most general method of dealing with torrents. The drawbacks to dykes are several. In case of a break in the dyke, the injury the torrent can do is concentrated. In this way a flood that without dykes would cause inconvenience and some damage by wide diffusion, would, in concentration and confinement, by a dyke system, do tremendous damage in any locality, where it might break through the dykes. This possibility is shown in the experience of dyked torrents in Europe and in great river systems, like the Po and Mississippi, as contrasted to the action of unconfined rivers, like the Orinoco and Amazon. A person who has seen a crevasse on the lower Mississippi knows what a failure in a dyke system means.

Dykes work differently in their effects on streams under different conditions. At the outlet of the Mississippi a jetty or dyke system scours and deepens the channel. This is not the case at the junction of two materially differing grades. A torrent coming out of a mountain range at say, a grade of one to five and then taking the valley or plain grade of one to fifty, is no longer able to carry the load of detritus it brought from the mountain. The dykes cannot always overcome this condition; consequently, the channel in the valley is filled up and raised. This necessitates raising the dykes. Finally a torrent so treated flows on a ridge. A break must be attended with great destruction. The most striking instance that I have ever seen of this effect of dyking was in the Austrian Tyrol on the Italian side. Above the old city of Boetzen, there is a water-shed made naked by communal pasturing. It is large and steep. This denudation created a torrent. To control the torrent, an extensive system of dykes has been erected and from time to time heightened to control the rise of the torrent channel. This system has cost millions of dollars to a comparatively restricted district. Several times bad breaks have occurred. From one of these, shortly before my arrival, two valleys had been flooded to the third story of the houses. Cattle, horses, etc., were drowned and many human beings lost their lives. The Tyrol was built up as it now is during the feudal regime. The population was concentrated in walled towns and the houses are therefore high. At Boetzen the houses are four and five stories. The evening that I arrived in that town, I went out

to walk and saw running by the city a very high bank, higher than the top of the houses. At one place, there was a stone stair. Going up this, I found a wide, gravelly stream-bed, quite dry on top, with the inside banks built of stone.

This was the torrent. The dyke walls had been raised from time to time to counter the channel raised from debris deposits.

The dyke system is not so simple as some people think it is. Surely it is a cheaper thing to prevent your torrent.

Dykes are also used to check and diffuse flood water. This is the Egyptian system. Diffusion and division of flood current requires engineering skill not easy to find.

Diversion of torrent channels from localities where they do damage to others where they do less, is a method of treatment that, under favoring circumstances, may be effective.

An interesting work of this kind exists at the Lake of Thun, in Switzerland. A torrent had been created there which was doing great and frequent damage. It was beyond any ordinary method of control. The plan of diversion was devised and carried out at a large cost, which has proved to be a great economy. The torrent was diverted to an artificial channel on a steep grade, through a hill to the Lake of Thun. The water in the lake at the precipitous point, where the torrent was delivered, was 200 feet deep. In a few years the torrent filled in an extensive area, and has made a delta for itself, where a short time before was deep water.

An important and valuable plan of torrent palliation for us is that of artificial rainfall storage reservoirs. A torrent that has once gained volume is almost impossible to deal with on this plan. The reasons are: First, that there can be no efficient method of flood diversion from a mountain flood in the mountains. If there were, your catchment basin, or reservoir, would soon fill with torrent detritus. Second, that a dam in the canyon of the torrent would soon fill with sand and stones, and might break and deliver an accumulation of flood water. Several dams in creek and river courses have burst, with damage and loss of life. Arizona has a number of such cases. The Johnstown disaster is one of the most notable cases in this country, both from the loss of property and of life. It was proposed by the miners to build a dam across the outlet of the Yuba to the plain, by tremendous blasts in the rock at the outlet gorge of the river. The object was to control the hydraulic mine slickens, which is artificial torrent action. The trouble with the plan was that the dam might

burst and do damage, the extent of which could not be foreseen, and that the silckens would soon fill any dam that could be constructed.

Reservoirs about the head-waters of our streams, as in such locations as Bear Valley and Hemet, will beneficially reduce flood and torrent action, while furnishing such held back rainfall for summer use.

Another method that has been quite extensively used is the cross-filling of canyon torrent channels with large rocks and boulders. This makes what may be called a half dam. It detains the detritus, and does also detain the flow of floods.

CHAPTER XV.

A SYSTEM OF FOREST MANAGEMENT A NECESSITY.

Forestry in the United States is still in its infancy. We have no system of forest management. Forestry with us is without form and void. The making of a forest system of management is before us in its entirety.

A Forest School, to provide a career for young men in the American forests, must formulate a system of management for the forests. We have none, and so we are forced to make it.

DEFECTS OF PRESENT METHODS.

The Department of Agriculture has had for some years a Division of Forestry. At the head of this division there have been several accomplished foresters and splendid men. The forestry division, however, has had no power. It has been, so far, little more than a literary bureau for forest missionary work, with an occasional technical monograph of value issued. Under its present chief, the work is developing in a promising way, but it can never accomplish results in the government forests while these are not in its charge and in no way under its control. The Department of War has sent detachments of the army into those parts of the forest reserve called National Parks, for some years. These army squads merely prevent injury to the parks. There is no pretense that the army is doing forestry work, except in preventing, or extinguishing fires. The power of dealing with the public forests is in the Department of the Interior, and is there delegated to the Land Commissioner, an officer with other large and absorbing duties. We thus have really skilled men in forestry in the Department of Agriculture, without power, and unskilled men in forestry in the Department of the Interior with such power as there is of making rules and regulations or a system, and of appointing a number of executive forest officers. Then in the Department of War is the only body of disciplined men in an organization of sufficient force to execute anything.

The forest officers of the Department of the Interior are all un-

trained men, without organization or discipline. However good men they are, very little forestry work can be expected of them.

This is truly an extraordinary condition of confusion. We must all work to have its radical defects cured. It is clear that the skilled forest officers are the men to formulate forest rules and establish a Federal forest system.

The present Federal system, if we can call it a system, is as follows: The forests are directly in charge of the Land Commissioner. This gentleman is not a forester. Under him are a number of Forest Superintendents and Supervisors. One of these has charge of all the forest reserves of Southern California. Until recently, the Forest Superintendent now having charge of the northern reserves resided at Redlands, in this district. Not one of these officers is a skilled or trained forester. Under the Forest Supervisors there are Rangers. It is claimed that most of the rangers are at least experienced mountaineers. These are few in number for the territory covered. Each one of these has a district assigned to him, which is necessarily very large. In such district he works alone. There is no system of checks by which it can be known where a ranger is or how much work he does. His duties are to patrol the district assigned to him, and to enforce the regulations about pasture that may be made at Washington. In case of a forest fire, he is to come out of the forest, if he happens to be in it, and gather up men and tools, and conduct this force back into the mountains to fight the fire. There can be but little expectation that such a body of hastily gathered men would be composed of experienced fire fighters. It is impossible that it should be a disciplined force. Time, which is of the essence of the contract in fighting fire, is fearfully wasted under this plan.

There is no system of fire prevention. Fire prevention is the one great thing to do to save our mountain watersheds.

It is claimed by the Land Commissioner that the law of the last Congress which gives citizens free ingress and egress to the forests, prevents any system of control of those entering the reserves, or the establishment of a permit, or even of a registry system for those going into the mountains. The law is bad, but it is not as bad as the commissioner thinks it is.

This entire plan of action has proved to be unsatisfactory. It has been inefficient in every particular. It is a practical failure.

Theoretically such a plan could not be expected to be efficeint. Supervision of officers is impossible. Fires are not prevented. No method is adopted to prevent forest fires. The plan of attacking a forest fire sacrifices time. When a fire does occur, promptness in getting to it is the key to success. Under this method prompt attack is impossible.

The water companies, resorts, irrigators and power companies most directly interested in the protection of our mountain watersheds, all agree in condemning the present plan of forest mismanagement.

PROPER METHOD.

With this destructive criticism, we pass to what the plan of management for our forest reserves in Southern California ought to be.

First, we can say that there are temporary and palliative measures that may be advisable. Of these we may mention the employment of army details for patrols, and a plan like that of Mr. Lukens for an enrollment of call men near the mountains. These to be picked and reliable men of experience, ready to fight fire at a given signal. This would be like the old town fire systems. This is a method still general in small communities for extinguishing fires of buildings.

The ultimate system of forest management must have a permanent and skilled force of men to carry it out. How shall we obtain such men?

There is but one way. This is by Forest Schools. Work and study in the forest is an essential part of every forest course. Civil service rules are a "sine qua non." Forestry is now a career in Europe and in India. There are also fairly effective forest systems in Australasia and in Canada. These forest systems all afford us valuable lines to work on. The conditions here, however, are "sui generis." The best system for American forest work in the great American forest reserves of the West remains to be formulated. It cannot be exactly upon any of the forestry lines heretofore or now followed elsewhere.

Our system of forestry has many different climates and conditions to meet. A complete plan cannot be expected to appear all at once and fully ordered to fill varying needs. It seems only prudent for us to outline a system for the Southern California reserves.

CHAPTER XVI.

OUTLINE OF A FOREST SYSTEM FOR SOUTHERN CALIFORNIA.

Force—This must be mainly permanent. Appointment to it must be on merit solely. It must be absolutely divorced from politics or personal influence. Its officers must be trained to the duties of forest guardians. Pending the creation of a trained force, the force itself should be used as a school. Its members should be made up of those who can pass the best examination in theoretical forestry. Preference should be given those making a study of the subject and declaring it to be their intention to make forestry a career. With the assistance of the agents of water and power conpanies and of resort proprietors in the permit or registration system and signal station plan, a force adequate for our immediate safety need not exceed thirty-six men. This force should primarily be divided as follows:

Trabuco	3 men
San Jacinto	5 men
Pine Mountain	6 men
San Bernardino	10 men
Sierra Madre	12 men

These allotments of men should be kept together and patrol their ditsricts as a body, in each case. Each patrol should have a captain, to be the best man in it. The patrol can be divided at times. There should never be less than two foresters together. The policy should be to keep the force united. There must be a system of check reports deposited at certain designated places to show the passage of the patrol. The chief forest officer must visit the patrol in the field from time to time.

STATIONS should contain the fire-fighting tools and imperishable supplies. Log huts can be constructed by the patrol for this purpose. The object of having tools at strategic points in the mountains is to save time in reaching a fire, and to save packing as much as possible. These stations should be at points accessible to the widest districts.

TRAILS. Trails must be gradually constructed from the stations to the various points designated for meeting fires within its fire radius. These trails can be best constructed after the fall rains commence or in the spring. In other words, the best time to devote to them is when the danger from fire is least. In open winters a great deal of trail work can be done.

FIRE BREAKS. These should be gradually constructed and carefully maintained along ridges, spurs and washes, as the topograpdy may indicate. The same seasons are appropriate for this work as for trails.

MAPS. The reserves should be mapped and districted as far as possible on lines of topography to meet and contend with fires. These maps should be numbered, so that signals could be given, so as to locate not only a fire, but the place, in any given wind, to fight it. The maps should also indicate the tool stations, the trails, signal stations and springs and streams. The map should be made to show the forest growth, the character of trees or brush, fire scars, etc.

MEASUREMENTS of springs and streams should be made from time to time. These measurements should also carefully note the condition of the watersheds, especially with reference to changes from fire injury on the one hand or re-forestation improvement on the other. Rain gauges should be set up in numerous places to ascertain the rainfall. With this, and the measured stream off-flow, we would know how conditions affected the rainfall delivery. Some of these gauges in the back mountains could not be visited often during the rainy season, and would therefore have to be large enough to hold a season's rainfall. Snow measurements should be provided for. The United States Signal Service rain gauge allows least evaporation, which in the seldom visited ones would be important. Many rain gauges can be arranged for with the various interests of our section, so vitally affected here by forest conditions.

SIGNAL STATIONS. These also can be arranged for without public cost, by the same interests. All persons I have spoken with having

interests in water or power companies, timber lands or resorts, tell me that they would cheerfully do these things to protect their own interests. Four such stations with the heliograph system would be ample for the San Gabriel reserve. Two would do in the San Bernardino range. It would probably be wise to ultimately have an alternating flag system for our rare cloudy days, and a colored light code for night work. Several stations should be set apart in the burned district for experimental tree-planting and re-foresting study and work. We all have a great deal to learn about re-foresting our Sierra. In fact, we have got to learn how and what to do from pretty near the head of the forestry alphabet.

PROVISION must be made for dealing with forest products. In the Southern reserves, practically all of what little merchantable timber there is, is in private holdings. But the handling of mature forests, to know how to provide for the sale and right use of ripe timber, should be studied. The principal thing remaining is the sale and use where possible, or gradual destruction, of fallen timber and limbs, to reduce the injury by fire and fire danger. This system cannot safely, at present at least allow the exploitation by private persons of wood or timber killed by fire. The sale of such wood must be by government foresters cutting and removing for the benefit of the service. The Santa Monica Ranch owners have twenty-five thousand acres in brush-covered mountains. They used to allow people to cut, remove and sell fire-killed brush. The result was a forest fire whenever wood brought a good price.

PERMIT OR REGISTRY STATIONS. No forest system can ever be effective in dealing with the paramount question of forestry in Southern California, which is fire, without a plan for permits, or, at the very least, registry for those entering the forest reserves. Prevention is the one great thing to provide for in dealing with forest fires. A permit plan will do this. Every road or trail into the mountain forests should have a permit station. Private interests will provide assistance in this matter on the San Gabriel, San Jacinto and San Bernardino reserves, and probably on the others. These permits should be in books, with a stub to be left in the book for each permit. The permit should be given free. There should be entered on the permit and stub the name of the applicant, his home address, the object of the visit to the mountain, the expected duration of stay, and the district to be visited. On the permit should be printed the rules of the

forest, and especially the rules for small cooking fires, prohibition of large bon-fires, and the rule obliging all fires to be extinguished by water, and a condensed statement of law and penalties for fire setting. This will at once insure responsibility on the part of visitors and inform them of the danger and penalties of careless fire setting. It will also furnish a clew for the apprehension of careless or malicious persons. Any one found by the patrol in the forests, without the permit, should be removed, and, when the law permits, be subjected to arrest and penalties. We will probably be forced to provide an alternative system, until present laws are changed, on account of the hostile attitude of the Interior Department to the permit system. The explanation of this opposition by the department is a law tacked on to the forest laws, at the last session of Congress, providing that citizens should have free ingress and egress to the forest reserves. I do not see that a free permit system would violate this law. It might be deemed a proper precaution to see that only citizens did thus enter the reserves without any regulation. Free transportation is always regulated by a pass or check system. Still, a pass holder travels free. This is so with other things of like free use, such as free theater tickets. When there is any class or personal privilege, it seems to be eminently appropriate, and in fact necessary, to see that the privilege is not abused or used by those not entitled to it. This Congressional law does thus discriminate againt persons not citizens. Therefore a free permit system must be lawful. Should the department fail to take this view, it can inaugurate a voluntary registry system, which would have much the same results. To each visitor could be handed a copy of the forest rules, as above outlined. Prevention of fires being the ideal method of dealing with our great forest danger, some provision of this kind to create a feeling of responsibility in the fast increasing campers and visitors to the forest, and to inform them of rules, laws and penalties of carelessness or criminality of fire handling should be adopted.

DEALING WITH FOREST FIRES.

The method of dealing with forest fires in California may be condensed as follows: Outfit, canvas suit, similar to hunters', strong shoes, shovels, brush hooks and axes. Shovel should have long handle. The handle can have hinge and bolt, to facilitate carrying on horseback. Some prefer rakes or pitchforks instead of shovels. For back-firing pitchforks should supplement shovels. There should be ample rations

and large water canteens, besides the individual men's canteens. There should be one man with a pack mule to carry water and rations, and, if practicable, an extra mule to pack blankets and tools. Fires should be attacked direct with largest available force. Promptness is one of the secrets of success in stopping fire. When wind is high, there is generally nothing to be done beyond going along the sides of the fire, out of range of the wind, to keep it from lateral spreading. When the wind permits, go well ahead of the fire, selecting natural fire break aids where possible, and back fire. The rakes and shovels can be well used here to make the back firing safe. An axe is often needed. Sacks with a little dirt in them and green pine boughs are used to beat out fires. I believe a shovel is better. Care must be observed to see that the accumulation of pine needles, often partly buried or out of sight, does not carry fire underground past the fire line, and start it up again. Fire on steep mountains starts small slides, and often sends large boulders bounding down the mountains. Therefore, care must be taken in attacking a forest fire that is coming down a hill. Another trouble with a descending fire, especially on steep declivities, is the fall of burning sticks or logs, which sometimes roll past the fire fighters and start the fire below these. This is a dangerous position. A fire going up a mountain can only be tackled at the ridge or summit. Ridges are natural fire breaks, and stop a great many forest fires. Wind and fire is the dangerous combination. In California there is during the dry season, when forest fires are usual, a trade wind that often blows quite briskly during the day. This breeze dies out at night, and is replaced by a very gentle down draft, generally in the opposite direction to the trade wind. In the day the sun also dries and heats the material, and makes the fire run more rapidly. Night and early morning are consequently the most effective times to fight forest fires. At night one is pretty sure to know whether a fire is out or not. This is not so easy to know in the day. Dead trees burning have to be watched or visited from time to time until they fall. A forest patrol should select the points of fighting fire in any watershed under its jurisdiction before there is any fire. This will greatly facilitate such work as may be needed in a fire crisis.

The response to fire signals to the patrol in the forest can be prompt. The patrol, with three to ten men, together, if they reach the ground promptly, can put out nine out of ten fires. What two men can do in limiting and extinguishing a forest fire within a short time after it starts, may take a hundred men to effect after it has

burned a day or two. We saw this demonstration in last year's forest fires. Some of these burned two days before any force reached them, and one at least five days. The ineffective system of last year still prevails. It is the plan of one ranger to a district, without checks, without signals, and who is expected to look up, outside of the mountains, a lot of men to help him. A patrol of trained men, having forestry in view for a career, with a signal system and patrolling in fair sized numbers together, can deal effectively with forest fires. The present system can never do it.

TORRENT STUDY. The forest officers will be under the necessity of dealing with this serious question as they have in Southern France. Extinction of the torrent by re-forestation will come next to torrent prevention by protecting the forests. Palliative measures will also have to be studied in the matter of dykes, their height and width, diversion, etc., as outlined in the chapter on Torrents.

SUMMARY OF QUALIFICATIONS FOR FORESTER.

What must a forester know to be efficient in Southern California? We may summarize the answer to this as follows: Know forest trees from each other, and their species and range; know fertile seed of forest trees; know how to plant and rear them in nursery form and in the open; know how to transplant and secure free growth on the mountains; know how to measure standing or cut timber, and how it should be cut for commercial purposes to secure the reproduction of the forest, and to prevent even temporary injury to water-sheds; know how to dispose of lumbering waste or fallen timber as a precaution against fire; know the effects of forest on rainfall delivery; (this includes the good effects of forests on the perpetuity of springs and streams, and the evil effects of forest destruction on flood and torrent action); know how to limit and extinguish forest fires; know the signal system; know the trails, roads, natural fire-breaks and water supply of his reserves; know how to make a trail; know what supplies are the least required for exigencies, and how to cook them; know how to pack tools and supplies on such animals as may be available for the character of country to be traversed; (burros are considered the most useful all-round mountain pack animals); know about game and fish in his district; know the laws governing forest fires, game and fish, and forest user and occupation; know how to take care of the physique so as to be fit for work; know how to advise or direct property owners in tree plantations, either in the

mountains or on the plains. There is a promising field for development in this latter line in Southern California.

He must know the geology of the reserves. This is important on account of the rainfall delivery from different geological formations, and also because different soils often vary greatly in the amount and kind of forest growth they will best support.

Finally, some attention should be given to appropriate sites for storage reservoirs, with sufficient watersheds and rainfall to fill them. The forester's work in this line will be in the nature of aid to the skilled Federal officers already charged with this work. The rain measurements on watersheds, together with the measurements of off-flow from them, provided for in our forest system, will be a valuable guide to an intelligent decision on the value of reservoir sites.

(The Coast Range is with us in several places in low hills, like the Mission, San Joaquin and Puente hills, and in other places we have rolling lands, not profitable for crops or orchards. Certain trees do well on these hills, and can be made a source of profit as well as prove a prevention to gullying and torrent action. At the same time, such tree plantations are likely to create springs, as was artificially done by Palissy in France by tree planting.)

CHAPTER XVII.

PHYSICAL QUALIFICATIONS AND CONDITION OF PATROL.

There should be a physical examination of applicants to the patrol. It is not necessary that such examination be as exacting as the present examination for army officers and recruits. Serious physical defects alone need be considered. Organic disease of the heart absolutely counter-indicates mountain patrol work. Outside of troubles and weaknesses that would be so apparent as to suggest avoidance of the physical stress of a mountain forest patrol, heart disease is about the only thing that should prevent appointment to the force. Life in the forest is health giving. The pure air and balsamic odors of our mountain forests together with the freedom from city nerve tension, the exercise and simple food would undoubtedly increase the health of all those in the patrol. The career of forestry is health and life giving. In this respect it is the opposite of such occupations as glass blowing and file grinding. Our race is not yet adapted to constant indoor life, such as our city careers so generally impose. Consequently life in the forest will make a man more vigorous and manly than life behind a counter possibly can.

The patrol once constituted, it becomes a first duty of the officers to maintain the health and full vigor of each individual in it. Without physical vigor the patrol cannot utilize any knowledge of forest conditions. To the extent that physical vigor is diminished, the efficiency of the patrol is diminished. This is true of all occupations. The question then is how to maintain the efficiency of the patrol for the forest work it undertakes. We must consider the health of the individuals in the patrol to do this.

PHYSICAL VIGOR—HOW MAINTAINED.

Let us take up salient points of management that are germane to this issue.

AIR. Avoid camp grounds that are relatively low or damp. The low lands in mountain valleys or cienegas are bad. The night air in such situations is always colder and damper that on mesas, ledges, or somewhat raised ground. Another reason for avoiding low camp grounds is the danger from sudden torrential floods. These floods are rare in our mountains, but they do occur. Such floods are mainly confined to the eastern part of the forest reserves that from time to time are covered by the Arizona summer rain belt. I have been a witness in both the San Bernardino and San Jacinto ranges of sudden and considerable local summer floods. The more denuded the watershed, the more violent and destructive these so-called cloud-bursts become. In the desert, where the low mountains are quite bare, these semi-occasional cloud-bursts will deliver for a few hours a tremendous volume of water. The experience of the railroads crossing the desert is a warning of how serious the rain delivery from a diluvial rainfall on a bare watershed is. In no part of the United States has the damage from washouts on railroads been so great as in the arid deserts to the east of us. Miles of track have been washed out even in the Colorado desert, dry and desolate as it is. And this, too, from short, local rains on the low, bare mountains. Oregon, with its sixty to one hundred inches of rainfall at the pass near Roseburg, shows us no such washouts as does Arizona, with its almost entire absence of rainfall on the deserts. In the one case forests detain and reservoir the great amount of water, so that danger is slight, and in the other the bare rocks shed the occasional water like a roof, which water destroys everything in its line of escape. Everything is afloat while it rains in Arizona, while everything is dry as soon as the rain is over.

Avoid low places and especially washes or dry torrent beds for camps. Take this precaution in an arid district more than elsewhere.

The result of a large rainfall in Oregon, with forests, and of a very small rainfall in Arizona, without forests, is a sermon on forestry that cannot be made more forcible. In Arizona, the high mountain districts, where forests still exist, show the same conservative effects on rainfall delivery as do our own and the Oregon forests.

WATER. The forest maps should show all points where water

——Cienega, low moist ground.

can be obtained in summer. This is of high importance in case of fire. In the summer the natural dryness of the air, when added to the extensive forest fires, causes an evaporation from men in action that must be replaced by a liberal supply of water. The patrol should know the nearest point in any part of a district from which the water supply can be renewed.

The water in our mountains is generally superior in quality; at some points, however, the springs are overcharged with minerals. These springs should be noted. Constant use of such mineral waters is likely to derange the system. Digestive troubles, calculus, kidney disease, etc., may result.

In the higher districts in the mountains, the springs are sometimes found very cold. This cold water, taken when in repose, is not dangerous. When a man or animal is heated by a hard mountain pull, or by fire fighting, these cold springs are injurious and occasionally fatal to users. Unfavorable effects are especially to be noted from cold water on heated animals.

I generally recommend tea in a ration for the special purpose of giving an excuse to have all water boiled. A body of men in the field must depend mainly on surface water for drink. Boiling such water removes its dangers. In traveling in Asia and Africa I have seen the immunity from sickness the sole use of weak tea for drinking gave, and the striking contrast of disabling sickness in large numbers of those not taking this precaution. I have seen the advantage of boiled water on many occasions. Boiled water also deposits a portion of its surplus mineral, which usually more than balances the evaporation. Thus boiling diminishes mineral contents especially in a covered vessel, from the lid of which the condensed evaporation may fall back into the vessel. In our mountains this practice has not the importance that campers on the plains would find. Officers and patrolmen will note, however, that resorts, tourists and even patrolmen can pollute and infect springs and streams. This danger must be guarded against. I do not think it would be of benefit to boil the water from the spring at the timber line of Grayback, but it would be to boil the water of the Santa Ana river just below Seven Oaks resort. It is the proper duty for the patrol to measure and analyze the water of all springs and streams in the forests. Some of these waters are medicinal, and if properly known, would deservedly attract visitors to California and doubtless aid in the return of health to our own sick people.

Water is, after air, the element requiring most frequent renewal

to maintain life in human beings. A man can do without food for a considerable period. Three to four days' fast is not necessarily fatal or even harmful. It is claimed that men have endured fasts of considerable periods. There is fair authentication of fasts exceeding forty days. The body can endure no such deprivation of moisture, or anything like it. The needs of the body in this respect vary with exposure and exercise. Heat, dryness and work together make a heavy drain on the liquid of the system. If this drain is not supplied, the entire body suffers. One of the striking effects of lack of water is derangement of the nerves and mind. The extreme sufferer becomes idiotic or insane. The importance of liquid to the system is shown by the injection into the veins of a saline solution, when an extraordinary drain threatens or has produced collapse. In the case of severe loss of blood by wounds, the recovery of system-tone by this procedure is surprising.

In a climate like ours, the water supply must never be neglected.

Many springs are of a small capacity. The marking of springs on the forest map should indicate the amount of water delivered. For springs the number of gallons or fractions of gallons delivered per minute is the most convenient measure, and one comprehensible to the largest number. A spring sufficient for one household might scantily sustain two, and fail entirely for three households. A mountain spring sufficient for one man only in the twenty-four hours may exist, but I do not know of it. All the springs and streams, however, have their limits of capacity in what life they can sustain. Most of them are large enough to leave this question unimportant for our patrol. There are a number of springs and water holes the capacity of which is insufficient for twenty men with horses and pack train. Consequently a patrol route and time card fixed upon certain springs for camps might be perfect for two or three men, but destructive and impossible for a large force.

A military expedition from Suakim, on the Red Sea, in pursuit of certain Bedouin tribes, lost nearly all its animals and was obliged to retreat from the African Desert, simply because the water holes relied on could not fill fast enough to supply the men and animals.

Dalton's experiments show that man requires in the temperate zone an average of fifty-two fluid ounces of water for his health and vigor per diem.

Care is required in bringing animals up to a water supply so as to prevent their rushing in and spoiling the water. Of course this acci-

dent can be corrected by letting the pool or spring stand, or by boiling the drinking water; or, if need be, you can take the mud to get the water. It is wise, however, to consider and guard against these drawbacks, both for yourselves and for your animals.

FOOD. There is no such thing as a ration suited to all men under similar conditions. There is no ration suited to one man under varying conditions. The best we can do is to approximate the ration to the requirements. This has been done very closely. A ration suited to a sedentary life would not be suited to mountain forest work. Neither would a ranger's ration be suited to a clerk or book-keeper.

Climate has a great deal to do in fixing the food best for human beings. In the Arctic regions fat, blubber, candles—in fact anything to produce heat is welcome and necessary to the system to resist cold. The natives of these frozen districts have their digestive organs permanently modified to meet these needs. This modification is fatal to them in the tropics, or even in the temperate region. Inhabitants of tropical countries have also a heavily increased death rate on going, or being taken, into cold countries. It is probable, therefore, that there are both permanent and temporary modifications of the human digestive system to suit both occupations and climates.

From these points we can see that a winter ration ought not to be the same as a summer one. The essential difference between a summer and a winter ration is the proper amount of heat makers for each. There is besides this also the form of the fat in the food to consider. Much grosser forms are appropriate for cold than for warm climates.

I have never seen this point much discussed. From personal experience and observation I believe it to be important. Fat is necessary in the tropics in some form. A summer ration even for one of our most fiery deserts should have some fat in it. Olive oil is the best form of fat for use in warm weather or warm climates. The Greek, Italian or Spanish plain laborers furnish us in their diet a ration that we know supports body and health, and fairly hard and long continuous work. Its defects seem to be in nerve food. In any event, these people lack initiative and energy in their own country and on their own diet, but improve in these respects in this country when they arrive. Whether the stimulus of change and hope for fortune in a new country, or the change in food, has most to do with the increased activity of foreign laborers immigrating to this country, we do not know. Both causes should be looked after.

I have seen hard work done in both Italy and Spain on a ration

composed of coarse, rough bread, onions or garlic, and oilves or olive oil. In Italy the southern laborers, I noticed, eat the black olive, such as we pickle here. The brine furnished them with salt. In Southern Spain there is the same square-set, heavy race, neither blonde nor brunette, that is found in the interior of Sicily. These people I have only seen casually loading or handling freight along the South coast of Spain, but then noted their use of olive oil on coarse bread. Olive oil is rather expensive and is an article of common use amongst but few of those likely to be in the forestry service. We could not, therefore, make it a part of the general ration. What we can do, however, is to introduce it and try the men on that form of fat, as compared to other forms. It is of special importance to find the best form of fat for human use in a climate as mild as ours is and to be consumed during the warmest season. Fats not only furnish body heat, but also nerve energy. In a warm or mild climate, that form of fat should be sought that goes most to energy and least to heat, except as a manifestation of such energy. In the tropics there are no strong civilizations. None have ever originated there. Even those primitive forms of society found in Mexico and Peru were on the high plateaux, and consequently in comparatively temperate climates. It is to be presumed that man originated in the tropics. This makes the absence of noted human advance in the moist warmth of these regions a subject of interest. Two reasons for this are theoretically presentable.

First—Civilization is the result of human energy. Energy is only possible by the development of heat. Heat in the tropics is already and constantly near that of the living, human body. Human energy in the tropics produces heat that requires other energy to get rid of. The greater the heat and moisture of the air combined, the greater becomes the difficulty of getting rid of surplus body heat produced by energy. The exercise and energy which we seek in the temperate zone is in part sought because we feel better physically because of it. In the moist tropics, exercise of body or mind is irksome and evaded because we suffer with the heat our own action creates. A dry-warm air enables the rapid evaporation of moisture from the body to easily neutralize the surplus heat. In very cold climates or very high altitudes, the energy required to neutralize the cold, prevents the human being from using energy for development. As there is no civilization that has come out of the tropics, so there is none that has come out of the Arctic Circle. The climate of Southern California is the type out of which all the great civilizations of the past have come. Doubt-

less we will be the civilizing center of America—a continent that needs civilizing just now.

To come back to our fats—we can remark that oil was the form of fat most largely used in both ancient Greece and Rome. This is still the case all about the Mediterranean. We produce excellent olive oil, and I believe that we would do well to use more of it.

Bacon is an excellent form of fat combined with meat. It is easily kept and easily packed. The salt used as a preservative aids its digestion.

Corned beef in cans is a good form of meat for a change.

We pass without comment the rubbish called canned roast beef.

Nitrogen is most easily kept and transported in the form of beans. Pork and beans with bread is a fine ration. The one point in beans is to cook them adequately. Thoroughly cooked, this food is not difficult of digestion. Imperfectly cooked, beans are a source of trouble. Cooking is a very important part of every ration. All foresters should have instruction in how to cook in camp. This includes the making of the fire and arrangements for cooking.

Salt is a prime necessity.

Pepper should also be provided.

Sugar is both a food and a stimulant. In proper amount, it is a great advantage in a ration.

Flour provides us with the hydro-carbons and various minerals. The more of the grain there is in the flour, the better it is as a food. Fine white flour is therefore not so good as brown flour or as whole-wheat flour.

A diet or ration without certain acids, and especially when composed largely of salted meats, is disadvantageous and ends in disease. Scurvy is a disease due to diet, and with the ration unchanged means prolonged and horrible suffering, ending in death. Sailors have been the greatest martyrs to this disease. It is, however, still common in prisons and in armies. Corrupt contractors, who do not furnish the food prescribed, are the probable present cause of scurvy. Potatoes and vegetables at the central camps will prevent this trouble. Dried fruit is also a good thing and easily packed. It must be examined, when exposed, to keep out moths and worms.

Lemons and limes are anti-scorbutics—easily procurable here at most seasons. Some anti-scorbutic should always be provided.

Variety in diet is always an advantage. Even a change of cooks is occasionally a good thing.

Stimulants or narcotics at the present time form a feature in every official ration known to me.

Alcohol was formerly quite generally a part of both army and navy rations. It is far less so now. Alcohol and tobacco are, however, still, officially or unofficially, quite generally used by men in organized bodies. In our California jails and penitentiaries these narcotics are replaced by smuggled opium. This shows us that while corruption in one place reduces or removes important parts of a ration, in another it can add an injurious element.

Alcohol is a narcotic as well as opium or tobacco.

We know by great numbers of experiments that all narcotics diminish physical power. All athletes are aware of this fact. I have used a glass or two of claret at my dinner for many years. It is to me a break or an ease-off of nerve strain. I know from repeated personal experience on a measured track, with a time-keeper and stop-watch, that even this amount of narcotic reduced my physical power.

Smoking reduces my mental power. While smoking I am incapable of the same mental concentration on any difficult problem that I am without it. I only notice this effect on occasions requiring continued and concentrated effort.

A brake is doubtless a good thing in its place. Going down hill from my ranch to the railroad there is one mile of stiff grade. A brake on my buggy gains me ten minutes' time on the drive. On the level, or going up hill, a brake set would be a disadvantage.

The narcotics, when we are off duty, may be an advantage, when used with care, in removing nerve-strain. The trouble with them and us is that we are so liable to use them to excess, or at inopportune times. In this way we get a physical or nerve brake on, when we are going up hill, to our very great injury. It is best to have none of them in use when on duty.

Smoking in our forests has the great disadvantage of its constant liability to set fires. I put out a fire in the Yosemite Valley set by a cigar stump, thrown out of a wagon just ahead of mine by one of the commissioners.

Last winter a small brush fire was caused in Eaton canyon by a cigar stump thrown out by a tourist.

I smoke myself, and consequently know what a tobacco prohibition means. Prohibition of smoking by foresters is, however, the only safe course.

Tea and coffee should be our reliance for stimulant or restful in-

fluences on our nerves. Tea is the easiest carried and the easiest prepared. Drunk in moderate strength it has no known disadvantages. Strong tea, however, in many produces nervousness, insomnia and deranges the digestion.

Coffee is a delicious beverage. It is not so well suited to camp life as is tea. To have its full value, coffee should be roasted and ground just before using. I have seen this done, while travelling, in tents in Asia. This preparation of coffee requires more time and trouble than that of tea. Tea is more agreeable also without milk than coffee is.

The hygiene of men, animals and camps can never receive too much attention. No knowledge of forestry you may ever have will be of any use unless you have the physical power to use it. There is nothing so disabling as sickness in an organized body. Powder and lead are not a circumstance to disease as destroyers, even in an army. Everywhere it is disease that disables most men engaged in war. Disease with us will be mainly confined to errors of diet or to polluted camps or waters. Our forests are free from dangerous malaria; the water, with few exceptions, is perfect; the air pure; the extremes of temperature never severe—in fact, we have all the natural conditions ready at our hand for increasing the health and vigor of our men.

A sound, healthy life requires sound, healthy morals. True moral life is a life in harmony with the laws of nature.

Marriage is one essential of a life in harmony with natural law.

Every man in the forestry force should be married by thirty. Preference in appointment should be given, other things being equal, to the married. This is not only in consonance with the highest statesmanship to preserve the population in its reproductive power, but also for the highest responsibility and vital strength of the forestry force. The recently published report of Wm. Farr, M. D., F. R. S., and Superintendent of the Statistical Department of the Registrar General Office of England, shows that the death rate of bachelors is very nearly double that of married men, at all ages. In France, it is eleven in the thousand for bachelors and only six for married men, between the ages of twenty to thirty. The same thing is true of women. A death is deemed to be accompanied by five disabled with disease. We can thus see how important marriage is as a vigor preserver. Between thirty and forty, the death rate is 12.4 for the unmarried and 7.1 for the married. Women who are mothers have a two years' better prospect of life than those that are not mothers.

I therefore advise all young men to marry early. If not for the State, then for their own health and longevity.

Life is a good deal like a rose bush. The thorns we have with us always. The only thing that makes the rose bush tolerable is its moment of love, represented in the rose. Life is but a straggling bush; the thorns are always present. It is sound sense to develop the roses, which can alone be done by healthy love.

CHAPTER XVIII.

DIETARY IN DETAIL.

As far as our digestive organs at their present stage of evolution are concerned, it has been ascertained with sufficient accuracy for all intents and purposes, what character and quantity of food is required for men in the temperate zone. We have prison diets, soldiers' diets, sailors' diets, etc., now arranged on a scientific basis in place of the old empirical one.

Yeo's table for the adult is:

Albuminous foods	100 grammes.
Fats	90 grammes.
Starch	300 grammes.
Salts	30 grammes.
Water	2,800 grammes.

Foster and Voit's table is:

Albuminoids	118 grammes.
Carbohydrates	392.3 grammes
Fats	88.4 grammes.

In these foods there is of nitrogen 18.3 grammes; carbon, 328 grammes.

Dr. Chaumont's table for an adult of 150 pounds weight and doing an average amount of work is:

Albuminoids	4.50 ounces.
Fats	3.75 ounces.
Carbohydrates	18.00 ounces.
Salts	1.12 ounces.

The British soldier's ration is:

Albuminoids	3.86 ounces.
Fats	1.30 ounces
Carbohydrates	17.43 ounces.
Salts	.81 ounce.

This ration is deficient in fats, and the high mortality of British soldiers in garrison may be attributed in part to this error. A con-

siderable part of this excessive mortality is in diseases for which fats are generally prescribed.

The following tables are taken from the Best Rations for the Soldier, by Col. Jos. R. Smith, M. D.

By general experience and individual experiment, we have discovered a certain amount of food which will sustain an average individual in good health; and, also, that much less than this will not suffice, though we do not know that a little less would not suffice. We have discovered, too, that certain combinations and proportions of different foods are best in the larger number of cases.

As large numbers of men are involved in these experiments, the application of "averages" comes to our aid, viz.: That property of the "average," in virtue of which, from a large number of specific cases, every one inaccurate in different directions, an idea may be deduced which is very near, indeed, to accuracy in the aggregate.

I proceed to give the amounts of food necessary to sustain in health and strength an adult male for twenty-four hours, as determined theoretically and (by experience) practically by different parties.

TABLE I.

Amount of food required per man per day, as determined in actual trial.

1.—By Prof. J. C. Dalton.

	Average.	
Fresh meat	16	ounces.
Bread	19	ounces.
Butter or fat	3.5	ounces.

Total solid food, 38.5 ounces.

For a "man in full health, and taking free exercise in the open air."

2.—Typical Ration of English Army.

Meat	16	ounces.
Bread	20	ounces.
Or biscuit	16	ounces.
Vegetables (fresh)	8	ounces.
Or vegetables (preserved) or rice or peas	2	ounces.
Sugar	2	ounces.
Tea	1-6	ounce.
Coffee	1-3	ounce.
Salt	1-2	ounce.
Pepper	1-36	ounce.
Lime juice (when fresh vegetables are not issued)	1	ounce.
Rum	1-2	gill.

Total solid food, Max. 46 ozs. to Min.. 36 ozs.

Lime juice at discretion of the general officer commanding, on the recommendation of the medical officer.

3.—Italian Army, Type B.

Bread	32.378	ounces.
Meat, fresh	5.291	ounces.
Bacon	.529	ounce.
Pastry (macaroni, etc.)	7.654	ounces.
Vegetables	1.763	ounces.
Salt and pepper	.7054	ounce.

Total solid food, 47.015 ozs.

In Nos. 3 and 4, wine, 25 centiliters; coffee, 15 grammes (over 1-2 ounce), and sugar, 22 grammes (over 3-4 ounce), should be added, being allowed.

4.—Italian Army, Type E.

Corn meal	24.689	ounces.
Meat, fresh	5.291	ounces.
Bacon	.529	ounce.
Vegetables	2.645	ounces.
Cheese	1.164	ounces.
Salt and pepper	1.411	ounces.

Total solid food, 34.318 ozs.

5.—Ration of the Army of the United States of North America.

Pork or bacon	12	ounces.
Or fresh beef or mutton	20	ounces.
Or salt beef	22	ounces.
Soft bread or flour	18	ounces.
Or hard bread	16	ounces.
Or corn meal	20	ounces.
Beans or peas	2.4	ounces.
Or rice or hominy	1.6	ounces.
Coffee, green	1.6	ounces.
Or coffee, roasted and ground	1.28	ounces.
Or tea	.32	ounce.
Sugar	2.4	ounces.
Vinegar	.32	gill.
Salt	.64	ounce.
Pepper	.04	ounce.

Total solid food, Max. 48.6 ozs. to Min. 32 ozs.

6.—Rations of the Navy of the United States of North America.

No. 1.

Salt pork	18	ounces.
Beans or peas	7.5	ounces.
Biscuit	14	ounces.
Tea	1-2	ounce.
Sugar	4	ounces.
Pickels	1.14	ounces.
Molasses	1.57	ounces.
Vinegar	1-2	pint.

No. 2.

Salt beef	16	ounces.
Flour	8	ounces.
Dried fruit	2	ounces.

Biscuit, tea, sugar, pickels, molasses and vinegar the same as in Ration 1.

No. 3.

Preserved meat	12	ounces.
Rice	8	ounces.
Butter	2	ounces.
Dessicated mixed vegetables	1	ounce.

Biscuit, tea, sugar, pickels, molasses and vinegar as in Ration 1.

Preserved meat	12	ounces.
Butter	2	ounces.
Dessicated tomatoes	6	ounces.

Biscuit, tea, sugar, pickels, molasses and vinegar as in Ration 1.
Total solid food, Max. 48 ozs. to Min. 36 ozs.

In the above rations, fresh meat, 20 ozs., or preserved meat, 12 ozs., may be substituted for the ration of salt pork or beef. Soft bread or flour, 16 ozs., may be substituted for biscuit. Coffee, 2 ozs., or cocoa, 2 ozs., may be substituted for tea; rice or beans, 8 ozs., may be substituted for each other. Vegetables of equal value may be substituted for beans or peas in No. 1, and for flour and dried fruits in No. 2. Canned vegetables, 6 ozs., may be substituted for dessicated vegetables in No. 3. Canned tomatoes, 6 oz., may be substituted for dessicated vegetables in No. 4.

The foregoing amounts of food are in avoirdupois ounces, and have undergone the test of experience.

Concerning the first, Dalton, in his work on physiology, says: "From experiments performed while living on an exclusive diet of "bread, fresh meat, and butter, with coffee and water for drink, we have

"found that the entire quantity of food required during twenty-four "hours, by a man in full health and taking free exercise in open air, "is as follows: Meat, 16ozs.; bread, 19 ozs.; butter or fat, 3½ ozs.; "water, 52 fluid ozs."

(COPY.)

Pasadena, Cal., April 17th, 1899.

Dear Mr. Kinney—Below you will find my list of food for one man for one year. This is made up from a careful account of food used on different trips. At first I would have a surplus of some things, and be very short in others, but of late years I have had neither trouble. If one or more of the party are especially fond of some one food they can take an excess of it, and less of something they don't care for. Where green vegetables are taken, take six times the weight of the evaporated. Nearly all new hands run out of salt in a few days; the amount I mention will not be any too much. Take plenty of matches, in tight-fitting covered can. Also, each person should fill a small vial with matches and seal with wax and keep in a secure place, so that if you fall in the river or get wet in rain you can start a fire. This list is intended for good living, where there is good transportation by pack animals or wagon, but for a trip on foot with no animals, one-half pound of grape-nut, with a little salt, will sustain life very satisfactorily for a week or two, with perhaps a little tea. Yours very truly,

(Signed) T. P. LUKENS.

PROVISIONS FOR ONE MAN FOR ONE YEAR.

	Pounds.
Salt	20
Flour	200
Corn meal	25
Rolled oats	25
Rice	20
Coffee	25
Hard tack	30
Mustard	2
Dried peaches (pared)	15
Prunes (pitted)	10
Raisins	10
Bacon	75
Dry salt pork	50
Dried apples	15

Baking powder	10
Butter—in sealed cans	20
Maccaroni	10
Two Edam cheese	12
Beans	35
Onions (evaporated)	15
Potatoes (evaporated)	25
Horse radish (grated)	2
Citric acid "Crystals" for vinegar and lemon acid	1
Extract of beef	2
One-half pint of Jamaice ginger, hops, food and medicine	3
Thirty packages Knorr's soup.	
Sugar (granulated)	75
Condensed milk, 24 cans.	
Twenty cakes dry yeast.	
One can black pepper.	
One ounce Cayenne pepper.	
One bottle Tabasco sauce.	

(COPY.)

Los Angeles, Cal., March 7th, 1899.

Mr. Abbott Kinney. Dear Sir—In compliance with your request for a list of the quantity and nature of provisions necessary for a week's supply for one man, I submit the following.

Bacon	4 pounds.
Corned beef (one pound cans)	3 pounds.
Flour	5 pounds.
Sugar	2 pounds.
Dried fruit	2 pounds.
Potatoes	5 pounds.
Onions	1 pound.
Beans (one pound cans)	3 pounds.
Coffee	½ pound.
Butter	½ pound.
A little salt and pepper.	
Baking powder	¼ pound.
Condensed milk	1 can.

It is necessary that one should carry a coffee pot, frying pan, small stew pan, water canteen, tin plate and cup and a knife, fork and spoons.

The above list is intended for one travelling every day and alone.

If a party are travelling together, it could be more varied, but about that amount is what would be required for one person. For a party of ten, it would not require ten times that amount. Less meat could be taken, and more flour and beans, and eight such rations would feed ten men. One person must carry more in proportion than larger numbers, as there is more waste, which can hardly be avoided.

I will be glad to furnish at any time any information which I may possess on forest reservations and the fires therein.

After the fire of last October I wrote an article descriptive of the damage caused by such fire to our present and future water supplies. In it I also suggested the formation of a popular Forestry Association for the purpose of co-operating with the Government in the protection of the watersheds, etc. I submitted the article to one of our newspapers, but it was returned with the remark that it was not timely.

I trust that your efforts to arouse public interest will meet with the success which the matter deserves. Very respectfully,

(Signed.) E. B. THOMAS.

416 East Eleventh street, City.

CHAPTER XIX.

SUGGESTIONS TO IMPROVE THE EFFICIENCY OF THE FOREST PATROL IN SOUTHERN CALIFORNIA.

The available funds for this purpose are now used in three ways, viz.: supervisors or officers, regular patrol and exigency patrol.

One head officer is necessary. Los Angeles is his proper location The other officers should either be on the mountains during the fire season, supervising the patrol and checking up its work, or removed and the money applied to the increase of the regular patrol. I consider these subordinate officers to cost more than they are worth at present, and especially with so little money available.

The exigency patrol fund should be applied to the increase of the regular patrol. There are exceptional cases where an emergency or exigency patrol would be an advantage. In such cases interested parties are ready to assist the work while the government funds remain inadequate. As a matter of fact all the large forest fires in the past two years have been effectively fought only by private interests such as the Mt. Lowe R. R. Co., Martin's Camp and the San Gabriel Electric Power Co.

Of the numerous reports I have of the exigency patrol fire work everyone condemns the system. In no case reported to me has a fire been controlled by an exigency patrol. The funds thus used are wasted. The exigency patrol system has congenital defects which render it impossible to make it effective.

First, Time: No one can gather up a fire patrol in a minute. In this chaparral country, time is the essence of the contract in extinguishing fire. Forest fires have here three stages; first, when it is small and starting; second, when it is in full force, roaring up the mountain; and third, when it is smouldering at natural fire breaks and creeping over into new territory. The first and third stages are those alone in which the fire can be controlled. Only little side work can be done when a forest fire is in full blast in our brush.

Now an emergency patrol cannot be organized to reach a forest fire in time to take advantage of the first stage. It is useless or worse at

the second stage, and ignorant, incompetent and undisciplined for the third. An increase of regular patrolmen, however small, would be much more useful than the exigency patrol. The work of exigency patrols has been reported to me in a number of cases. The shortest time was the patrol sent to the Henniger Flat fire. This fire was on the south face of the Sierra Madre within two hours of the City of Pasadena. The patrol reached the scene of the fire the next day, sixteen hours after it started, and after the fire was out. The Martin's Camp force and my Water Company force stopped this terrible fire at natural fire breaks on ridges and in washes. This is not a criticism of any officer, but of an impossible system. Too much time must be wasted in reaching a fire by this method. Reports on other exigency patrols show that from two to five days elapse between the starting of the fire and the arrival of the patrol.

Generally these exigency patrols have been hastily gathered in towns and cities. The character of men thus recruited is not of the best. There can be no discipline in such a force. They are not properly clothed or shod for mountain fire work. They do not know how to fight fire. They do not know how to care for themselves either as to water or food. Few of them are physically fit for the arduous work. If, on the other hand, you have call men located in and about the mountains for exigency patrol work, you are very likely to have fires occur when other sources of money are stagnant, a frequent condition with this type of men. It is charged now that forest fires have been set and renewed to secure work on fire extinction. An exigency patrol is not of much if any account. Three or four intelligent and capable men can do more good on fire work than a hundred corner loafers pitched into a brush mountain on fire. I wish it clearly understood that no officer is criticised. It is the system which is at fault.

The money saved by cutting off some of the subordinate forest supervisors and thus saved by dropping the exigency patrols, would double your present regular patrol in all the most dangerous districts in the south.

At the present time the forest reserves in Southern California are divided into patrol districts. In each of these there is one patrolman. These patrolmen have no defined relation to each other. In case any one of them needs help he goes to the nearest point at which communication with an officer can be had and asks for it. Valuable time is necessarily lost in this way. What would seem better would be as follows:

Arrange the camps of the rangers at the points contiguous to the greatest number of districts. In this way, with the present force, three to four men would have their camp together. At this central camp would be the tools for fire fighting and trail making. Supplies could be delivered at these camps and the head officer visit them for reports and inspection. It would cheapen the cost of telephone or signal system. The rangers now have to come out of the mountains for supplies and once a month to make a report. By the above method the ranger would not have to leave his district. He would also have company and aid. The rangers of districts so arranged should be instructed to give each other aid.

The fire signal should be an imperative call for assistance with tools. The fire signal in this section is plain and unmistakable. It is a cloud by day and a column of fire by night. In this way at least four competent men would be after a fire at the first sign of smoke. In most cases enough of them would reach the fire in the first stage to control it. The economies suggested would enable the dangerous districts to have a double patrol. Eight trained men would then be promptly available for fire work. Very few fires would get beyond the first stage by this system and all would be dealt with by a good force at the third or resting stage. All forest fires of wide range go through this third period several times in their course. The recommendations of the Forest Society, now being partly carried out, were:

1st: That the rangers should be appointed Deputy U. S. Marshals. This the U. S. Marshal in this district refused to do. A marshal could be appointed who would do this. In one district the rangers have been appointed Deputy Sheriffs by the county. In all the Southern reserves most of the rangers have been appointed deputy game and fish wardens, at the suggestion of our society to the Fish and Game Commission. These stars enable the Rangers to arrest offenders against State laws. The stars also add greatly to their influence and power.

2nd: A free permit system was suggested. Any one in the mountains without a permit would be taken out. These permits were to contain, with a duplicate register on a stub in the permit book, the name and address of the holder, the part of the Reserve to be visited and the person's object. At the bottom was to be printed the rule against large fires and obliging every fire set to be extinguished by water and the penalties for setting forest fires. Every permit holder would surely be in a more responsible frame of mind with the permit than without it, and would use more care. Ignorance could not be pleaded as to the fire

rules and laws. Permits would prevent forest fires. Prevention is better than cure. Our attorneys deemed this permit system to be entirely in accord with the last Congress' law on the forest reserves.

In place of this permit system there has been quite a general action by the Rangers in taking the address of persons met in the mountains and warning these on the fire dangers. This is better than nothing, but it is not complete. The permit system is complete. All the companies interested in water, power, resorts, etc., in the mountains, would aid in this by keeping the permit books and issuing these without cost to the government. These companies have stations now at all the entrances to these southern mountains.

3rd: Trails to be built by rangers as time served. Some rangers have done a little of this, but there is no regularity or plan about it. What the Forest Society recommended that could be done by the present force that has not been attempted at all, was:

1st: Map making, to show natural fire lines, water sources, trails and timber. However rough such maps were they would be a great aid. Two of our society rangers have made such maps.

2nd: Recognition of Forest School started here.

3rd: Measuring water in springs and streams and setting rain gauges.

4th: Collection of tree seeds to be planted in burned districts.

Your future system of reserve management in the south should provide for a permanent force. In winter the rangers should receive instruction in forestry and prepare seedling trees for planting and plant them as funds permitted in the burned and denuded districts. They could also make trails and maps during this season; build log huts at the central range stations; erect telephone lines, etc.

In this connection, there is a movement started by the Forest and Water Society to have a part of the 800 acres of the National Soldiers' Home at Santa Monica used as a grand National Botanic Garden. All the trees that will grow in the United States will grow there on its plains, canyons, foothills and mountains. This would be the place for a forest training school and forest tree propagation for re-foresting. We would be glad to have you help the movement.

The Division of Forestry should be placed under the Commission of Lands, Dept. of the Interior, or else the forestry work should be turned over to the Division of Forestry, Dept. of Agriculture. It is an anomaly that the only division of the government service dealing with forestry should have nothing to do with national forestry work. Our Forest and

Water Society is of the opinion that at least in all the arid district where the great bulk of the remaining public land is, the public lands should be managed as a unit. The mountain forest lands should be considered as a reservoir system to store the rains, maintain springs and prevent torrents. Reservoirs and irrigation should be developed and paid for by the sale of the improved lands. All the public lands fit for pasture should no longer go to the strongest and most violent but be leased under proper rules to preserve the pasture, prevent bloodshed, protect the forests and give some return to the people of the United States who own them. The money available from such rents is estimated to be, from the public lands in California alone, from $250,000 to $500,000 a year.

THE AUTHOR TO LAND COMMISSIONER AT WASHINGTON ON FORESTRY SYSTEM FOR SOUTHERN CALIFORNIA.

Oct. 9, 1899.—Hon. Binger Hermann, Land Commissioner, Washington, D. C. My Dear Sir.—Your kind favor of the 19th ult., requesting my suggestions on an improvement in the Forest Patrol system, has been received. Your request is complied with in a separate paper herewith enclosed.

We all appreciate your interest in the forestry question. We also appreciate at least in part the difficulties that surround the creation of an efficient forest system. You have had to create a system fitted to deal with very divergent conditions. This work had to be done without previous American landmarks and under circumstances that made European experiences of but small value.

Lack of funds has also been a most serious handicap to your efforts.

The government under your administration of the Land Office has accepted the responsibility of caring for and managing the government forests. You have earnestly undertaken a great work, which will be the starting of an epoch in the west. While we believe that the system can be improved, it is a pleasure to say that the work in this section has been better done this year than last. We desire to aid your great work in all possible ways. Permit me to present two important considerations in regard to Southern California forestry work:

1st: Southern California conditions are different from those in any other forest reserves in this country. The climate, topography and industries here demand a care of the water-sheds nowhere else so

urgent. The forest growth is chaparral or brush. Only in the canyons and high ridges is there any timber and this so scattered and inaccessible as to be out of any calculation for revenue product. There are a few exceptions to this when timber in sufficient amount grows to be available for commerce. These districts are in private hands. Chaparral is the principal covering of the mountains. No other forest reserves have this predominant chaparral character. Where the fires have gone the springs and streams have dried up. Existing torrent cones and increasing flood damage warn and unite our people in a desire for forest protection, which is self-protection.

2nd: The forestry movement here is not on the same footing as it is elsewhere. Here the theoretic and aesthetic basis of forestry is secondary. Every irrigator, water company, resort, establishment, railroad company, power company, and in fact all citizens, are actively favorable to forestry. There is no sheep or grazing industry of any importance here using the forest lands for pasture. Only on the north side of the mountains, and mainly in the Pine Mountain reserve, is there sheep invasion from the San Joaquin.

This community is for forestry for immediate and practical reasons. Conservation of the water supply and prevention of torrents is the life question in Southern California. What I said to you in the Palace at San Francisco over a year ago was that the situation in Southern California could only be realized by a personal visit from you and inspection of the vast interests dependent on irrigation and a view of the chaparral covered mountains, of the great fire scars, of the dried springs and torrent damage. No one can realize the situation without seeing it.

Your letter indicates that our printed plan of management, together with several of my letters to you, must have miscarried. Please advise me if you receive this one. In case I do not hear from you, I will forward a copy to a friend in Washington to be delivered to you personally.

Yours respectfully,
ABBOT KINNEY.

PRINCIPAL FOREST TREES OF THE CALIFORNIA RESERVES.

CHAPTER XX.

PRINCIPAL AUTHORITIES ON THE SUBJECT.

The men who have described the forests and forest trees of California have all written poetry into their descriptions. True poetry is that higher insight that inspires the soul. Indeed, it is but natural that the poetic feeling should be shown when the grandest forests of the world are being brought to the knowledge of mankind.

Muir's "Mountains of California" is oue of these beautiful descriptions of our mountains and their forests. It is well worth the forester's study.

The earliest attempt, of any importance, to give a complete scientific description of the forest trees of California is that of Sereno Watson and Dr. George Engelmann, in the "Botany of California," published in 1880, uniform with the volumes of the Geological Survey of California. The order Coniferae was largely written by Dr. Engelmann, the most acute student this group has had in America; and his judgment is likely to be the final one in regard to our most difficult species.

Next came Prof. J. G. Lemmon, who treated of the forest flora of the Pacific Coast as an entirety by itself. This work was done under the orders and at the expense of the old State Board of Forestry. It is to be found complete in the biennial reports of the State Board commencing with that of 1887-1888. Like a number of the works in these reports, it has been republished in several editions. No State reports have received the same amount of quotation and republication by private enterprise as those of the State Board of Forestry. The State should republish these reports.

The latest and much the most elaborate work on the trees of this country is by Professor Charles S. Sargent, "The North American Silva," in thirteen volumes. Vols. 10, 11 and 12 treat of the Coniferae, containing plates of the flowers leaves and cones of all our species and varieties and a vast amount of information in the text.

Forest Giant and New Growth.

FOREST GROWTHS.

For the purposes of the forester, it is only essential to present at first the most important forest growths, with the expectation that the student will finally know all the forest growths by mountain study. Nor will we now go beyond the reserves themselves in our tree examination.

The forests of the reserves in California are predominantly evergreen. While there are a few deciduous trees, the black oak, "Quercus Californica," and the hickory oak, "Q. chrysolepis," are about the only ones of general importance. Speaking in a broad way, our reserve forests are evergreens and belong to the order of the Coniferae. That is, the trees are cone bearers. Our California conifers are divided into three tribes, the Cupressineae, Taxodineae and Abietineae, with characters as follows:

Tribe I. Cupressineae:

Scales of fertile aments, opposite, in pairs, becoming a small dry cone, or a drupe-like berry in juniper; leaves opposite or ternate, often dimorphous, a large tribe of four genera: Juniperus, the junipers; Cupressurs, the cypresses; Thuja, white cedar; Libocedrus, incense cedar.

Tribe II. Taxodineae:

One genus only; Sequoia, the big trees.

TRIBE III. Abietineae.

A large tribe of five genera:

No. 1—Abies, the firs; leaves sessile, leaving circular scars when they fall; cones erect on the upper limbs, their scales deciduous from the axis; seeds with resin vesicles.

No. 2—Pseudo-tsuga, Douglas spruce; leaves petioled (stalked), the scars transversely oval; cones pendulous; scales persistent: seeds without resin vesicles.

No. 3—Tsuga, hemlock; branchlets rough from the prominent persistent leaf bases; bracts of the cone smaller than the scales; cones pendulous; seeds with resin vesicles.

No. 4—Picea, spruces; trees having also character of the last, except leaves sessile; seeds without resin vesicles.

No. 5—Pinus, pines; cones requiring two years to complete their growth (three years in two American and one European species), their bracts becoming corky and thickened, leaves (the conspicuous foliage) in fasciles of two, three or five (solitary in one species), and surrounded at base by a sheath of scarious bud-scales; pollen two lobed.

Timber and Timber Line on Sierra Nevada.

The lumber trees in our reserve forests are the pines, firs, Douglas spruce, incense cedar, and in one district of the Sierra Nevada, the sequoia.

Of the pines, there are but two in our reserves that as yet are an important source of lumber. These are the yellow pine and sugar pine.

The incense cedar is principally used for posts, ties, shingles, etc.

In our southern reserves the yellow pine is the principal lumber tree. The sugar pine is indeed the king of the pine genus, but it has a much more restricted range than the yellow pine, and but seldom grows in masses. It is scattered through the forests of the middle Sierra region. One of its peculiar properties is its straight grain and facility for splitting. This invites the woodman to it for a source of shakes. No lumbering in our mountains is more distressingly wasteful than shake-making. Only parts of these giant trees are used, and quite frequently the woodsman tires or the tree proves refractory. Thus it happens that the mountain traveler often sees sugar pines of two to two hundred and fifty feet in height felled, with only a few feet of the trunk used. The rest remains to rot, or furnish destructive fuel to some forest fire.

(Foot Note: All of our lumbering is very wasteful. Under private ownership and at present lumber prices, it will so continue, without a forest system. A method has been proposed whereby the cutting of lumber by private parties or corporations might be so conducted as to promise a new forest crop and remove the danger and destruction by fire, usually severe in cut-over districts on account of the lumbering waste. This method is that rules be drawn up by foresters for the tree cutting and removal of waste. The consideration to the lumber companies to so conduct their cutting being an agreed price to be paid by the government for the cut-over land thus treated. The rules to secure forest safety and insure new growth are simple and not costly. A number of lumbermen have expressed approval of this or some other fair and reasonable plan. The only other way out of this difficulty is by expropriation of private timber holdings. There is, however, an increasing interest amongst lumbermen in a private forest management to secure continuous crops. This will surely grow with higher prices.

A good deal of cut-over forest land is allowed to go delinquent for taxes. Such lands, while falling back into the people's hands, fall into State or local jurisdiction. This result is not satisfactory, because the State has no forest system and, besides, has no part in the management of the Federal reserves.)

CHAPTER XXI.

STUDY OF TREES.

One of the interesting things about our forest trees is that these have such a tendency to grow in pairs. This fact will simplify your study of the trees.

PINES, HOW DISTINGUISHED.

Taking the grand yellow pine as our most important forest tree, we find that it has a brother called the Jeffreyi, or black pine. Let us commence with these in furnishing points not purely botanical for identification. First, how will you know a pine from any other conifer of our mountains? You can know them by the leaves alone. These, whether short or long, single or in bundles, are always needle-like and always in a sheath at the base next the branch. That is one point, and it is enough. When you find a cone bearer with a needle-like evergreen leaf, with a sheaf from which the leaf or leaves spring, it is a pine. The only other genera of the sub-tribe "fasciculares" are the cedrus and larix, neither native to California.

The name of the yellow pine is pinus ponderosa. It is a splendid tree of very wide range and several varieties. Its habit is straight, of regular form and it grows tall, 120 to 300 feet. The leaves grow out of their sheaths in threes. Their color is medium green. Their taste and odor aromatic and piney. The leaves are from four to ten inches long.

The yearling cones are green and of rather oval form. The mature cones are brown and generally small, three or four inches, although sometimes four to five inches long. The cones always break off the tree, usually leaving some of the scales on the tree. From this it is called a base-broken-cone. It is always widely open when on the ground. The general shape is ovate-conical. The seeds are about one-half an inch long with wings an inch long. Male flowers large and long. The typical bark is a bright salmon color, very thick and fissured into large plaques, suggesting the skin of an alligator. No other pine has bark like it. The great stem of these pines, when thus typical, is a beautiful and grand column of the forest, recognizable as far as one can see it.

Tamarack Pines on Alpine Lake in Sierra Nevada

From this type, the bark varies with less and less striking color and marking to dark, almost black color and longitudinal fissuring. These darker barked varieties in California usually have the larger cones, and for the most part are found in the lower altitudes, where the ponderosa grows. Nor are these dark barked varieties as tall or as large as the salmon colored plaque barked, small coned ones. The dark bark is not so thick as that of lighter color, and there is a larger proportion of sap to heart wood in the dark trees.

These varieties in the cone and bark have persuaded some botanists that the yellow pine's brother, Pinus Jeffreyi, is but another variety and not a true species by itself. Better acquaintance corrects this mistake.

The black pine is found in the higher altitudes and is at its best about 7,000 feet above the sea. It is also found at lower levels. In Northern California the black pine appears to affect hotter, drier ground than P. ponderosa and at about same elevation.

The striking differences between these species are as follows: The yearling cones are purple instad of green, with larger prickles. The mature cone is much larger, more base broken and of pyramidal shape, and not so flaringly open when ripe. The leaves are covered with a delicate silvery powder, not present in ponderosa. Their taste and odor are much more delicate and sweeter. In fact, these pines have songs of their own, tastes of their own, odors of their own, and wood of their own. The yearling cone color is enough to separate these two species, even to the most casual observer.

There are several varieties of Jeffreyi also with bark color, varying from brown in broad check to dark red and black, with lateral fissures.

While these varieties of form make some confusion for the beginner, these species can be separated by an examination of the yearling cones and a careful look at the foliage; the silvery powder of the Jeffreyi is, however, very light on the leaves and has to be looked for and rubbed off to be sure of it. The taste and smell of the leaves is very different. That of the ponderosa is strongly of the pine, while that of the Jefferyi is delicate and suggestive of oranges.

This pair of pines is easy to separate from the others by the broken base of the cone. Other cones that are base-broken are those of the long persistent cone-holding pines. Such cones are forced off by the growth of the tree, or by violence.

The first pine you meet in the foot-hills of the Sierra Nevada is

Granite Dome and Upper Timber Line Pines, Sierra Nevada.

a nut pine with a large edible seed. It is sometimes 180 feet high. This is Pinus Sabiniana. It is of a branching, forked, or rather straggling growth. The trees are generally far apart and mixed with white oaks (Q. Douglasi). Its leaves are long, of a dull gray color, and the foliage is usually so thin as to offer but little shade. The cone is long persistent on the tree. This pine is frequent in the Tehachapi. Gray-leaf pine seeds are large, black, sweet, and with a very hard shell; a favorite Indian food. It is not found in our neighborhood. The cone is very large, dark colored and with hook-like spines. Two other pines take its place in our neighborhood ranges. These are P. attenuata (P. tuberculata of American authors) and P. Coulteri. P. attenuata is a small, straggling tree with green foliage and a long knobby cone. It is a rather poor looking tree. It also grows on hot foot-hills. A striking peculiarity of this tree is that its cones remain firmly closed for indefinite periods, often until opened by fire. Thus, when a fire kills these trees, a plentiful sowing of seed for a new growth takes place. A few of this species are found in the Sierra Nevada warm belt.

I forget whether it was Muir or Lemmon who noticed the uniformity of age of trees in tuberculata or attenuata groves. This we may assume to be due to its habit of seding all at once after a fire. In such fires the old trees seem to have been killed. Some people think that this tree resists fire better than others. I find no adequate confirmation of this opinion, unless it be its method of producing new trees after a scorching fire.

P. attenuata is scarce here, as elsewhere. It is found on the south face of the San Bernardino range.

The other foot-hill tree, P. Coulteri, is quite handsome, with green foliage, leaves in threes and never to be mistaken, on acount of its gigantic hooked cone. This cone is the largest in the world. When mature it is of light color, growing darker on the ground, and is armed with large, curved hooks. The cone is quite persistent, so much so that the tree wood often grows around the base so as to enclose some of its scales and cause it to break like base-breakers. The male flowers are cream color. The cone weighs from five to eight, and, it is said, even ten pounds. It was first found in the Santa Lucia mountains, where it is in a forest of its own. In San Bernardino, it ranges from 1,800 feet to 7,000 feet above the sea. It makes fair lumber. The seeds resemble those of P. Jeffreyi.

The curious Torrey Pine has an unusually large cone. Its foliage

Pines in the Sierra Madre Summits.

is rather dull grayish. It is only found in a few places, with a few trees at each, along the San Diego coast near Del Mar and on the island of Santa Rosa. The trees are not very old and there is no sign of any former extension of the species. In fact, it seems more like a new adventurer to the State. It comes easily from the seed. The leaves are in fives. Along the San Diego coast this pine crouches and lies on the ground and rocks of the bluffs and barrancas to resist the sea breeze, much as P. flexilis and P. albicaulis dwarf and creep under the Sierra snows and winds.

Once in our high southern mountains, the forest is of P. ponderosa, cedar, sugar pine, firs, Douglas spruce and, in damp places and higher up, of the tamarack pine. With these, in the lower levels, is the golden live oak (Quercus Chrysolepis), and in the middle, higher, the deciduous black oak with large edible acorns.

Let us go on with the pines. The chieftain of pines of the whole world is Pinus Lambertiana, the great sugar pine. This giant is not plentiful in the Southern Sieras. It is easily recognizable, both in its detail and general appearance, from other pines in our mountains. The stem or bole is long, without limbs. The bark is of a dark reddish brown of warm effect, finely fissured. From wounds in it issues a sweet pine gum that is edible in small quantities, and very laxative in any amount. This gum has given the tree its common name of sugar pine. The leaves are much shorter than those of the yellow pine, and are always in bundles of fives. The leaf color is a pleasant blue-green, very different from the sad, dull gray of P. Sabiniana. Its most striking characteristic is the fruit. The cones are the longest in the world—ten to eighteen inches. These hang generally in clusters far out on the long branches, and bend these down in graceful curves. The seeds are large, sweet and edible, but very difficult to get. The mature trees have great individuality of form. The foliage is often quite thick and concentrated about the top. The branches stretch out over the lesser forest trees in an adventurous, independent way. One tree lover has suggested them to be the priests of the forest, forever extending a benediction to their fellows.

The sugar pine leaves have less of the pine taste and odor than any other tree of the genus.

Pines generally are inclined to a stiff, formal growth. The sugar pine has nothing of this. Each of these trees has character of its own. Each tree is interesting as an individual. In fact, the sugar pine is

Yellow Pines (P. ponderosa) Sierra Madre Mountains.

amongst the most strikingly individual trees we have. Its brother, the Pinus monticola, is not known to me in our Southern Sierra. It is found in high altitudes of the Northern Sierra, from the headwaters of the Tule river northward, and usually above the sugar pine belt.

P. monticola, like the sugar pine, has five leaves in a fascicle, and the foliage of the two is similar in color and texture. It is usually less than 100 feet in height, with a trunk stout in comparison, covered with a blackish bark, which is suffused with a rich, dark red tint. Its cones are pendulous and green when young, like the sugar pine cones, and resemble that species in the texture of the scales, but only four to six inches long usually. This species has for an associate Abies magnifica, the "Silver Fir" of certain portions of the Sierra Nevada; and the two forming the upper belt of the thicker forest, are the most important protectors of the headwaters of the reservation rivers, and the chief builders of the forest-floor at these altitudes.

Above P. monticola in altitude, in the great Sierra reservation, occurs the thinly scattered, but beautiful "Fox-tail Pine," P. Balfouriana. Sometimes it forms an open park-like forest, as at the southern base of the Kaweah peaks, and west of Mt. Whitney and Sheep mountain. It has the stout and comparatively short trunk of P. monticola, but its leaves, in fascicles of five, are short, stiff, forming cylindrical plumes at the ends of smaller branches, hence the common name of "Fox-tail pine." The cones are nearly the size of those of P. monticola, but the scales are of different texture and form, and chocolate purple when young.

There are also two alpine pines that grow dwarfed near the Northern Sierra snow line, above the Fox-tail pine, that have some characteristics of the sugar pine. These are P. flexilis and P. albicaulis, the former much rarer than the latter. The twigs and branches of the alpine pines are very tough and flexible to resist the weight of snow by which they are crushed down. Very old trees of these alpine pines are often found only a few feet high, but widely spread over the rocks. Sometimes one can walk over their tops, just as you can over a close cropped cypress hedge. I do not see how anyone in our mountains could be troubled to recognize the five-leaved, long coned sugar pines.

In the damp alpine valleys and on the edges of meadows we find the tamarack pine (Pinus Murrayana). Its brother pine is the P. contorta, a northern maritime pine. There is an extensive forest of the tamarack pine on the northern base of the tree line of Grayback,

Forest Growth on Sierra Madre, 5000 feet above Sea.

Pine Forest Sierra Madre, 6000 feet above Sea.

while in the Sierra Nevadas they cover thousands of acres at an elevation of 8,000 to 10,000 feet. It is very easily recognized. Its leaves are short and in twos. That is a character in our mountains that is conclusive. The bark is very thin, brown, with a chrome yellow veining. It is easily wounded so as to bleed and gum up. This, and the thin bark, make it an especial mark for the fire demon. It suffers more from fire than any forest tree we have. The leaves are of a strong, dark green. Altogether, it is a handsome tree. Cones small (one and one-half to two and one-half inches) and seeds small.

The last of our mountain pines is the pinyon (P. monophylla). This is a generally short branching pine, justly celebrated for its excellent edible pine nuts. Its foliage is of an agreeable bluish color, not cold and forlorn like the foot-hill pines. Nor is it so bright and handsome as the sugar pine coloring. This pine has a wide range along the eastern base of the Sierras and over into Nevada and Arizona. There are many handsome specimens about Bear valley in the San Bernardino range and also along on the east side of the Sierras in smaller form; a few are found scattered on the west side. There is one on the summit of Mt. Lowe. The pinyon can always be recognized from the fact that it is the only pine in the world with but a single leaf to the sheath.

While the Monterey pine is not found in any of our forest reserves, but is confined to a small district about Monterey, and with a variety on the island of Guadaloupe, it has been more planted than any other native tree of California, except the Monterey cypress. From this reason we should give this pine some attention. Its foliage is in fascicles with three leaves each, a bright green, and is very dense. The cone, when mature, is ovate-conical, oblique at the base, three to five inches long, tubercles at base outside large; prickles small deciduous. Seeds pale, strongly reticulated with brown; wings an inch long, beautifully veined with reddish brown. Bark thick fissured, very hard, black without, bright red on inner face (Lemmon). A variety with two leaves exists on the island of Guadaloupe, and elsewhere. The attention given to this tree in mild climates is due to the remarkable rapidity of its growth. It is the fastest growing pine known. It is from this cause called in foreign countries the "Remarkable Pine." The Monterey pine is suited in California to districts near the sea, or subject to sea influence. In these places it is hardy and long lived, and grows well in light sandy soils. In the interior, however, where the air is dry and the climate warmer and

El Capitan, Young Tree Growths iu Protected State in the Yosemite.

more continuously sunny, this pine has a tendency to short life and commences to die out after the tenth year, especially where the soil is also dry. In these respects it resembles the Monterey cypress and the blue gum or Eucalyptus globulus. All of these trees support the conditions of our interior valleys very well when water is near the surface, or when irrigation supplies them with moisture.

Logging in California.

CHAPTER XXII.

CEDARS AND OTHER FOREST TREES.

Next, we will take our cedar: Libocedrus Decurrens. The first or generic name means "Incense cedar." This name is derived from the fragrance of the wood when cut into. The second name is due to the small scale-like leaves, which are decurrent. The foliage is flat and massed, of a bright green livened up with yellow tendencies. The bark is light brownish yellow, deeply furrowed and thick. The tree is striking, and has no close relative in our Sierra. The incense cedar, once seen, cannot be confused with any other local tree.

The spruces are represented in the California forest reserves only by the genera Pseudotsuga and Tsuga, or hemlocks; the first by two, the latter by one species. The spruces can be distinguished from the firs by the position of the cones on the branches; in the former they are pendant near the ends of the branches; in the latter they stand upright and are mostly lateral. Moreover, the scales of the spruce cones adhere to the axis long after maturity, and even for several years. The cone scales of firs fall as soon as ripe—in September or October.

Pseudotsuga is characterized by a straight and perfectly erect leader or terminal shoot, by leaves which spread every way from the stem, and large cones (three to six inches usually), whose three-lobed sharp-pointed bracts project beyond each rounded cone scale. The hemlocks or Tsugas are much more graceful trees, whose terminal shoots, especially in younger trees, are slender and recurved-drooping, whose leaves are in two nearly opposite rows on the stem, making usually a flattish branch, and whose cones are smaller than Pseudotsuga cones (one to two and one-half inches), never with projecting bracts. Both of the above genera have short-stalked leaves, while the Piceas, or true spruces, represented in California by the Sitka spruce and the weeping spruce, in the northwest part of the State, have no stalks to the leaves.

The only hemlock of the reservations is the alpine species, Tsuga mertensiana (formerly T. Pattoniana) occurring near timber-line in small groves from Mt. Tallac to the head-waters of Kings river. It

Showing Black Oaks of the Sierra Nevada in the Yosemite Valley—Young Yellow Pine in Left Foreground.

may be known by its dark green, short and dense foliage, the slender habit of the tree and the slender nodding terminal shoot. It is certainly one of the most beautiful trees of the north, for it is found even in Alaska.

Pseudotsuga taxifolia (the P. mucronata of some authors) known under various names, such as "Douglas spruce," "Oregon pine," "Red fir" (although it is neither pine nor fir) comes into the reserves from the north, like the hemlock, and extends southward along the Sierras, at the same elevation of the cedar and Yellow pine, in decreasing areas, to the Yosemite Valley and the headwaters of the San Jouquin river. Its bark is black and rough like the old White firs; but its foliage and branches are much less stiff than the firs. The leaves are very fragrant and are even preferred by some to those of the fir for pillows.

The spruces are represented in the southern reserves by the Pseudotsuga macrocarpa. This tree was considered for a time to be only a variety of the great Douglas spruce, but now its specific standing is recognized.

The Macrocarpa is mainly distinguished from the Douglas spruce (Pseudotsuga taxifolia) by the greater length of its cone. These pendent cones are often quite long. One of their peculiarities is the growth of the bracts beyond the cone scales from an inch to an inch and a half or more. These bracts have two teeth and a central projection. There is another cone that far exceeds the bract growth of the Macrocarpa. This is the cone of the Abies Bracteata, a species of fir confined to the Santa Lucia mountains. The bracts in that case are more like long thick switches.

Our two firs are the white and red. Abies concolor, the white, and Abies magnifica, the red or balsam fir. The firs are very handsome trees with dense, dark green foliage. In youth, and sometimes in the older white firs, the tree is quite silvery from the numerous stomata mainly on the under side of the leaves. The bark is rough, thick and furrowed. In the white fir, the bark is lighter in color. In the balsam fir, the bark is dark or reddish. The fir cannot be mistaken for any other of our mountain trees, because, first, its cones are erect or stand up on its branches, and second, because the cones do not drop off entire. The scales drop off piece by piece, leaving the cone axis persistent for a long time. For this reason, one does not find fir cones on the ground. The red or balsam fir can always be distinguished from the white fir by the delicious, persistent and penetrating fragrance of the foliage. Mountaineers select branches of the balsam fir for their beds

A Burned District in the Sierra Madre. Unburned Forest in Foreground.

on this account. The leaves are picked and put up in pillows or sachets, in which this tonic and pleasing odor is long maintained.

The California nutmeg, with its long, prickly, needle-like, shining leaves, and its fruit resembling a small, green plum externally and a nutmeg internally, is related to the Conifers, and will be found sparingly along stream-banks in the northern or Sierra reservations.

Here also, at much higher altitude, among the bare crags below Farewell Gap, and near Half Dome above the Yosemite Valley, grows the Western juniper (Juniperus occidentalis). Its foliage is cypress-like, and its fruit a small blue berry, but its trunk is remarkable for its great breadth as compared with its height.

Sequoia gigantia, the "Big tree" or "Redwood" of the Sierras, is so well-known and is so conspicuous from its huge light brown or salmon-colored trunks, its crown of cypress or juniper-like foliage and small oblong cones, that it requires but brief mention. It appears on the National parks and reservations rather frequently south of the Kings river in Tulare county. Northward to Placer county the small scattered groves are mostly in private hands.

These are the outline sketches of our leading forest trees. The few striking characteristics of each mentioned it is hoped will enable the student to identify the species and then to complete a knowledge of them by personal observation.

There are, in wet places and along canyon streams, some other trees we should not entirely neglect.

The alder is the dense foliaged, dark green leaved, deciduous tree on the lower mountain water courses. In these, we also find the native maple. The native Bay tree is another water seeker. This handsome evergreen becomes more scattering and finally disappears from the canyons as we recede from the coast. Its leaf has an intensely pungent odor. In the Coast Range canyons in the northern part of the State, where the bay, "Umbellulaia Californica," grows into a superb tree, I have been oppressed after a foggy night on going into the canyons as the sun come out by the powerful odor of the bay trees.

The sycamore and cottonwood poplar go out in the canyons and washes toward and into the valleys.

The California cottonwood poplar is a remarkably hardy tree, standing both alkali and rocky soils, and the alternate frosts and fiery heats of our high deserts.

The poplar has two species here, the principal one being P. Fremonti, the cottonwood, and the other P. Trichocarpa, the Balsam pop-

Douglass Spruce in the Sierra Madre

lar. The former of these has flattened leaf stalks, downey leaf buds and the young wood is light or yellowish in color. The latter has shiny, sticky leaf buds, round leaf stalks and dark colored young wood.

The Mesquit is a fine tree for alkaline and hot places. Its wood is a great heat maker. I have seen fine, large tree specimens of Mesquit grown in the San Gabriel Valley. It is native to one desert district.

The California walnut, "Juglanus Californica," has a sweet nut with a thick, hard shell. It grows along in the tertiary foothills. This makes a handsome shade-giving tree in cultivation, or even without care. It is deciduous.

We have also willows, elders, etc. The elder makes a remarkably durable post.

Out on the plains, we have the white and red live-oaks, both beautiful trees. The red oak is very much the most attractive and often runs pretty well into the canyons, and accompanies the sycamores out into the washes.

Timber and Timber Line, Sierra Nevada, at Cathedral Peaks.

CHAPTER XXIII.

FISH AND GAME OF THE FOREST RESERVES.

Charles Frederick Holder.

The splendid domain know as the Forest Reserves, reaching from Lake Tahoe on the north along the Sierra Nevada mountains, and including the ranges of Southern California to the Mexican line, is a natural park thousands of square miles in extent, embracing features so varied in character that it has become world renowed. Its scenery is impressive beyond description, and the Sierra Nevada range alone, with its stupendous ravines and gorges, reaching from the land of living glaciers about Mount Dana to the semi-tropical regions of its foothills, is a world in itself. Within its borders are alpine lakes, trout streams and pools six or seven thousand feet above the sea. The black-tailed deer and grizzly wonder through forests of titanic size—a nature's wonderland. In the heart of this region are rifts, gulches and canyons, so narrow and abysmal that the light of day rarely reaches into their depths. Here is the home of the receding glacier, and other more ancient giants of snow and ice have left their mark as clearly as the eroding hand of time itself. There are strange contrasts in this natural park. Cliffs a mile high, mountains which in their height and rugged splendor challenge the world; alpine lakes scintillating like gems; streams which flow along the mountain tops, born of winter snows, leaping madly over precipices half a mile high, as in the Yosemite, foaming among the rocks, finally to emerge into the broad valleys of the summerland below and flow on amid nodding flowers to the sea.

The Forest Reserves may be considered the land where the game animals of the State have made their last stand, and where they should find adequate protection. Not fifty years ago, vast herds of elk roamed the Reserves; the antilope covered the San Joaquin and other valleys in bands, while deer and bear were the common animals of nearly the entire region. Now they are so rare that the antelope has almost disappeared, the elk is but a memory, and in the extreme southern section the grizzly, the most common animal half a century ago, is only occasionally seen. In the inaccessible portions of the Sierra Nevadas the grizzly, Ursus horribilis, is still fairly abundant, and the black bear,

The Mountain Lion.

Ursus Americanus, and several varities, as the cinnamon, are to be met by the hunter along the river bottoms, well representing the large carnivora. Unlike the bears of the extreme north and east, those of the southern Reserve do not hibernate completely, roaming the forests in search of food almost if not the entire year.

In this natural park, perhaps more plentifully to the south, is found the Leon del monte—the mountain lion, Felis concolor, of California and the West; the largest American cat, remarkable for its wide geographical range. It is seen in the forests of Washington and Oregon; as the puma it ranges the deserts of Patagonia. I have followed its trail as the panther in the deep forests of the Adirondack mountains, and have seen its footprints on the keys of Florida near the mainland where it swam from key to key, the very antipodes of the ordinary feline, at least in ths respect.

The carnivora is well represented in the forests of the Reserve but only those which are considered game will be mentioned. It might be considered a stretch of the imagination to apply this term to the lynx, two species of which are known in the mountains of California, but I have witnessed their courage and ferocity on many occasions when followed by hounds. The spotted lynx, Felis maculata, is a striking and beautiful creature, often seen in the foothills and main ranges of Southern California, and is a southern representative of the great northern lynx. It can be traced as far south as the City of Mexico. The other species is the red lynx, Felis rufa, common everywhere in California; both forms being known as wild cats in many sections. They usually make their home in the mountains but are the familiar of almost every large arroyo coming down these roadways and so reaching the foothills of the Southern California mountains. They frequent the luxuriant tangles of wild grapes and the thick brush of the orroyo bottoms, living cheek by jowl with the raccons, skunks, wood rats, raccoon-foxes, and other small carnivora which make up the interesting fauna of the region.

In the upper ranges, more particularly in the Sierra Nevadas, though rare even there, lurks the gray wolf, Canis lupis; as ghostly, grim and gaunt as the fancy has painted it; skulking among the big trees, or stealing down the canyon, perchance eying some sheep herder, far away. This animal is rarely seen, especially in the southern portions of the Reserves, but on the eastern slopes of the Sierra Nevadas it becomes fairly common, and in the adjacent territories is considered a menace to the best interests of the herder. In California it is found in the

upper Sierras, running in small herds, and preying upon deer. Another wolf is found in this vast stretch of woodland, though on its lower levels, where it breaks up into foothills. This is the lowland wolf, the coyote, Canis lutrans, one of the most characteristic aniamls of the West. The coyote is a hanger-on of civilization, the familiar of town, village or hamlet, making its home in the ledges of the foothills, perhaps in burrows or natural caves from which it emerges at night, traveling long distances down the valleys to visit the hunting grounds of its choice. At such times is heard its strange laughing bark, whicn has so marked a ventriloquistic quality that one coyote can easily convince a novice that a desperate pack of lowland wolves is lurking about the stock. The coyote follows the arroyo beds down into settlements and ocassionally preys upon domestic stock, but its game is the ground squirrel, the jack rabbit and cottontail, which it is very expert in taking. It occasionally varies its diet, being fond of grapes, guavas and possibly other fruit. The coyote is withal one of the cleverest of its tribe and may be said to be the jackal of America.

Among the hoofed animals of the Forest Reserves, five typical forms stand out: the black-tailed deer, the mule deer, the antelope, mountain sheep and elk. The latter, owing to the lax legislation of past years, have nearly disappeared, but the two former, it is believed, are holding their own. The elk* is included as it is thought that a few are still to be found on the slopes and foothills of the Sierra Nevadas. When California was discovered the horns of this magnificent animal were seen from San Diego far to the north. The clumsy mule deer—Cariacus macrotis—with long ears, is occasionally seen, its large size making it a conspicuous object. It is a mountain and lofty plateau form. In the Sierra Sadre and Coast ranges of the southern portion of the Reserves it is rarely seen, its place being taken seemingly by a smaller variety which has been described by Judge Caton. This deer is especially common in the ranges which reach down to the sea from Point Conception south.

In the leafy coverts of Southern California, the arcades formed by the alder, willow and bay, where the canyon streams splash out into the open and the manzanita, wild lilac and holly grow, one may meet the black-tailed deer (C. Columbianus), while farther north it ranges in the

*Mr. H. W. Keller, late Fish Commissioner, writes me: "The only elk I know of in this State are a few in the northern part of Humboldt county, and about one hundred and fifty in Kern county, west of Bakersfield."

upland regions and is the typical deer of the Forest Reserve. I have seen it on the slopes of steep canyons which radiate from the San Gabriel, where it finds almost absolute protection in its resemblance to the chaparral; a dainty little creature, as graceful as an antelope, and while affecting the deep brush, it may be seen in the wide washes, or in the early morning on the mountain edge of some remote ranch. This beautiful deer ranges up to an altitude of five or six thousand feet in Southern California, frequenting in summer the groves of large trees on the summit of the Sierra Madre mountains; in winter it is driven down to lower levels by the snow.

Not many years ago the Forest Reserves were the home of the bighorn or mountain sheep—Ovis montana—the representative in this country of the nayaur of Nepaul and Thibet; a noble animal to have met comparative extermination at the hands of the pot hunter. The male has an imposing armament in its curved and creased horns which attain enormous development. The animal may still be found from one end of the Reserves to the other; but hunted from peak to peak, from plain to valley for years, without laws for its protection or hunters to obey a law if it was in force, it has gradually disappeared, and it would be difficult to find it in the southern ranges today. I have seen three heads of bucks taken on the slopes of San Antonio within the past ten or twelve years, and doubtless a small flock still holds its own on the precipitous sides of this mountain; but unless game laws are enforced, the complete extermination of the animal in California will soon be accomplished.

One of the crimes of the century was the destruction of the bison. Another is the wiping out of the only American antelope—Antilocapra americana—which is now in progress. It is the most interesting and graceful of all the American ungulates representing the great African family in America. Formerly vast herds could be seen in the San Joaquin valley, and undoubtedly it ranged all the valleys of California. It is a lowland form affecting the great stretches of level lands and valleys which characterize California; but it often strolls up the canyons, small herds having been seen browsing on the foothills of the southern and central portions of the Reserves. This animal is the swiftest of all game and but for its singular curiosity would be rarely captured. This fatal habit has resulted in its almost complete extermination in California. Sportsmen and others steal upon the herds, and by standing on their heads, or waving a limb with a red or white rag, or exhibiting
11 any strange object, they can attract the attention of the timid animal

California Bear.

which, urged on by its curiosity approaches, step by step, until within range, and then pays the penalty. Other hunters who commend themselves more to the true sportman, hunt the antelope upon the great plain and run it down upon horesback—a most difficult and dangerous pastime.*

Among the rodents of the Reserves is the jack rabbit, or more properly, the jack hare, Lepus californicus, a typical and interesting form. It is found all over California, in the southern portion of the State, living in the upland valleys, as the San Gabriel, and in the brush which borders the chaparral of the slopes of the Sierra Madres. In the great valleys, as the San Joaquin, adjacent to the Forest Reserves and the Sierra Nevada mountains, these animals abound in vast numbers and are a menace to the farmer. The natural enemy of this hare is the coyote, and I have always opposed the slaughter of the latter, believing that it was a vital error. The coyote may kill a few turkeys and chickens, but it also devours thousands of these tree girdlers. The hare is a swift runner, yet the coyote outwits it in long chases. The jack rabbit does not burrow, forming a crude nest among the scant brush of the open plain. This is often disputed from the fact that the animal is sometimes chased into holes by the hounds; the retreal, however, is the home of the burrowing owl or a badger. Living more completely in the ranges are the cottontails or rabbits, several species of which inhabit the foothill regions of the ranges of the Forest Reserve, and have a decided economic value.

In the deep canyons of the Sierras the stroller may see perched upon a branching limb a gray squirrel with a silver brush, out of all proportion to its size, folded gracefully over its back. This is the gray squirrel of California, Scrurus fossor; a little creature which to me is one of the charms of the beautiful canyons which open into the San Gabriel and other valleys of Southern California. With these are chickarees, or chipmunks, whose graceful movements are a constant delight to the observer.

BIRDS.

Ranging down from Northern California into the Forest Reserves in the desert side of the Sierra Nevada is the sage grouse, Centrocercus urophasianus. It is, as an ancient epicure once said of the do-do, more

*Mr. H. W. Keller states that he found about seventy-five antelopes about forty miles east of Yreka, Siskiyou county, running in the timber, and a band of twelve in the west end of the antelope valley. "I do not think," he writes, "that there are five hundred antelopes in the State."

White Oak Grove at Chico, California, Showing Young Oak Growth Amongst Old Trees.

pleasing to the eye than the stomach. It is a fine appearing bird, the largest of the family in America. The courtship of the male is a remarkable performance, during which the bare yellow spots indicating the air sacs are enormously expanded, producing a strange sound. Perhaps the most peculiar feature of the bird, is that unlike all other gallinaceous birds it has no gizzard.

The common grouse of the Forest Reserves is the Sooty grouse—Den dragapus obscurus fuliginosus—also called the California grouse

Head of Quail, Life Size.

by some sportmen. Mr. F. S. Daggett tells me that me that he has seen it on the head waters of the Tule river, and has shot it at the head waters of the Kern river not far from Mount Whitney. It inhabits the evergreen forests of the Sierra Nevadas six thousand feet above the sea in summer, but in winter is found on the lower spurs at an altitude of two thousand feet. In the early spring the wanderer through the forests may hear the remarkable love note of the male, produced by con-

tracting and inflating the large air sacs found one on each side of the throat. Unlike the sage grouse, the bird is desirable as game, the meat being of excellent quality.

High in the mountains, up to the very snow line and far beyond, we find a bird somewhat larger than the Eastern Bob White, yet calling it to mind. Its dark-blue breast, the tints of crimson and white, the four bands of white, the bluish head. and above all the two jaunty slender plumes which rise like quill pens that might have been tucked behind it ears, tell of the mountain quail—Oreortyx pictus—one of the most artless, beautiful and characteristic game birds of California. Its note is sweetly modulated, sounding like "cloi, cloi, clio," or "quit, quit, quit," strangely resonant in the wild rock-bound regions of its choice. I have never had the temerity to shoot the bird, as at each attempt the birds in flock of ten or fifteen, instead of flying, approached me, walking directly along until within forty or fifty feet, then standing and with expressive gestures endeavoring to solve the question as to who this intruder was. Their heads were extended forward in wonderment as they eyed me, their plumes vibrating, and for a moment they were silent; then came sweetly, "woi, woi," or "tch, tch, tch," from somewhere in the brush, and the pattering of feet on the dried leaves began again and the mountain qauil went their way.

Every wash and canyon, every elevated plateau along the borders of the Forest Reserves is the home of the valley quail,—Lophortyx californicus,—fast disappearing before the insatiate sportmen who reckons numbers as the test of skill, In former years vast bands of these attractive birds could be found all over California, affording much sport and possessing a decided economic value. If the mountain qual or patridge is jaunty and debonnaire, what can be said of this lover of the valleys whose sweet note, "ka-loi-o," with the accent on the second syllable, comes softly on the wind. The female is a demure little creature, but the male, with its splendid attire and graceful plumes, is the type of all that is attractive and beautiful among game birds. The head marked with white, the back a slate blue, the swelling breast black, white and cinnamon; a collar of white, the nodding plume which, as the birds run, bobs up and down before their eyes like a pom-pom out of place, constitute an ensemble which gives this quail a marked individuality among the game birds of the world. In early spring, when the land is green the nest is formed beneath some bush, and when the sun is high and the glory of the poppy begins to fade, and the ground is carpeted with the twisted seeds of alfileria, long velvety lines of young

may be seen running in and out among the late flowers. The espionage of the mother is not needed long; in a few days the young birds can fly, and a few weeks later are members of some big flock which fillls the air with a roar of wings as it rises to plunge over the divide into some deep ravine.

FISH.

The lakes and trout streams of the Forest Reserves commend themselves to the lover of nature and sport. In the north lies Lake Tahoe, with its system of lakes and tributary streams and brooks well stocked with trout. About Mount Whitney are glacial lakes, while the river which forms the Yosemite Fall, comes down in one stupendous leap of half a mile, rushing boisterously through boulders and rocks to form

A Night Catch of Trout at Bear Valley Lake.

later a trout stream; eddying through banks of flowers and arcades of grateful shade to the summerland below. The streams of the southern portions of the Reserves are like nearly all the characteristic rivers of Southern California dry at intervals and often throughout almost the entire length from the mountain to the sea, but in reality flowing on beneath the deep sand bed in which they are seemingly lost. Such are the San Gabriel and Los Angeles rivers, the Santa Ana at times, and others which can be traced into the green heart of the Sierra Madre mountains, where under normal conditions they are rushing, living streams, the home of the rainbow trout.

The Sierra Madre range, representing the southern portion of the Reserves, is cut by the rains and melting snows into myriads of canyons, whose sides are well wooded or covered with chaparral; and hardly a canyon, with its high beetling cliffs, but is a river of verdure, a source of delight to the stroller. These trout streams rise high in the range, often twenty miles in its very heart, and flow on over polished rocks and boulders beneath the sycamore, bay and pine; now out into the open, by masses of wild lilac and California holly, heavy with its bunches of vivid red berries

In ascending such a stream the trail winds across it again and again, and it is not in the deep pools that we shall always find the largest fish, but along shallows. Here is the home of the rainbow trout,—Salmo irideus,—a marvelous creature in blue, silver and red, ranging up to six pounds and more. This is the common trout of the Coast Range and of the Sierra Nevada mountains. About it there is a little mystery. Some affect to believe that it is merely the young of the Steelhead, while others contend that it is a distinct species. The existence of this fish is seriously threatened by over zealous anglers who fish for numbers alone and who take out the small fry by thousands every year.

The largest trout of the southern portion of the Reserves is the steel head,—Salmo Gairdneri,—a magnificent creature, attaining at times a weight at times of twenty pounds, and leaping when hooked four or five feet in the air. In the Santa Ynez it finds its way forty or fifty miles up into the range to spawn. It is a most attractive fish in appearance, having a rich olive-hued back, sides gleaming with silver, while the head, fins and tail are dotted with black. In Southern California the Santa Ynez and the adjoining streams are its favorite haunts; where excellent sport is had in early spring, the fish coming in at this time to spawn

In the Kern river, which rises in the Forest Reserves, is found an ally of the rainbow trout—the kern river trout (Salmo irideus Gilberti). It attains a weight of seven or eight pounds; is dotted with pronounced spots of black, while older individuals have splashes of orange on the under jaw. In the very heart of the Forest Reserves, on the slopes of Mount Whitney, and living in the cold waters of the melting snowbanks, the most beautiful of all these fishes, the Golden trout, (Salmo irideus agua-bonita), is found. It seems to be confined to the streams on the west flank of Mount Whitney, tributary to Kern river, and is especially abundant in the south fork of Kern river and Volcano

creek; it is also found in the streams about Owen's lake, and he who observes it in its haunts must climb to lofty heights and enter some of the most inaccessible regions of the Sierra Nevada range. So brilliant and scintallating is this little creature that to seems to have imbibed the nectar of yellow gold that has filtered down through the rocks of ages. Its upper surface is a delicate olive; the sides blaze with golden lights and hues, while the loteral line is vivid scarlet. The belly has a broad scarlet band, the lower jaw is bright orange, and orange splashes or spots are upon other portions, making it the very harlequin of the tribe an example of what altitude, the high Sierras, and peculiarity of environment will accomplish, as this living flash of gold is undoubtedly a wanderer from the Kern river, and a variety of the trout of that stream previously described.

In Lake Tahoe is found the large trout known as the Tahoe trout, silver trout, or Truckee trout—Salmo mykiss Henshawi; a radiant creature usually caught at eight or ten pounds, but ranging up to twenty-nine pounds, possibly more. The largest specimen ever seen, which weighed twenty-nine younds, was presented to General Grant. The Tahoe fishermen recognize two forms in its deep waters—the "pogy" and "snipe," the latter the young, but the fishes are identical. They spawn in the lake and affect the clear deep water of this attractive body of water. The Tahoe trout is colored a dark green above, silvery upon the sides; but in the salty waters of Pyramid lake it becomes a lighter green, the sides having a flush of coppery red. On the lower jaw there are spleshes of red, while the head bears pronouncd black spots—an adornment which makes it a striking and resplendent creature. The specimens I have taken were from the artificial lakes about San Francisco and were a disappointment, but I understand that the fish in its native streams and in the big lake at Bear Valley, and its tributaries, where it has been introduced, displays game qualities which give it high rank among sportsmen and anglers.*

In the limited space of a chapter but a mere mention or enumeration can be made of the principal animals which inhabit the Reserves. There are many more which while not strictly game, render the great ranges of California and its forests one of the most fascinating resorts for the naturalists, layman or sportsman.

*Besides these native forms, the Reserves and lakes have been enriched by the introduction of several kinds of trout, among which are the Scotch trout, German brown trout, Eastern brook trout, and the Mackinaw trout.

FORESTRY AND IRRIGATION.

"*He calleth for the waters of the sea, and poureth them out upon the face of the earth, the Lord is His name.*" **Amos, 800 years B. C.**

CHAPTER XXIV.

SOME RELATIONS BETWEEN FORESTS AND WATER SUPPLY.

By H. HAWGOOD, M. Inst. C. E.

We must start out with the fundamental principle that the waters of the earth derive their existence from the heavens above. There is no spontaneous process of production, no water manufactory in the recesses of the earth. The water which falls upon the earth in the form or rain or snow passes away in flowage and evaporation. By flowage is meant the underground movements, as well as the visible surface streams of the springs, brooks and rivers. Evaporation includes the direct evaporation from the surface of the ground, from objects animate and inanimate, and the water which is taken up by plants and transpired as vapor through their leaves. And while not strictly correct, the much smaller portion of water that is permanently absorbed into plant structures may, for simplicity's sake, be charged under the common head of evaporation.

We now have a simple expression of supply and demand. Total rainfall equaling the sum of flow and evaporation. It is from the flow that practically all waters for the use of man are drawn. For the primitive direct collection of the rain from house tops and other exposed surfaces, is on too minute a scale to be given a place.

Evaporation decreases the quantity of flow. Floods decrease the flow available for economic purposes. The total quantity of water being fixed, whatever rushes past in a torrent to the sea is lost for useful ends.

TWO-FOLD EFFECTS OF FORESTS.

The problem before us is to trace what influence forests may exert upon these points of rainfall, evaporation and floods, and see what foundation there is for the almost universal belief that they increase the one and decrease the other two.

Many meteorological stations in connection with forestry have been established in France, in Germany, in India, and elsewhere. In this country the subject has also received attention, but on a more limited scale. Progress in the conclusive establishment of definite effects has necessarily been slow. It is an unfortunate fact in regard to all subjects connected with rainfall, that systematic observations must have been conducted over a long series of years, forty to sixty, in order to obtain data upon which to predicate positive results. The records of a few years may be, and they frequently are, very misleading. The secular meteorological changes tend to move in cycles of wet periods and drouth. No conclusions can be safely accepted that are not based on records extending sufficiently back into the past to include and give full weight to these cycles.

RAINFALL IN PHILADELPHIA.

The records of precipitation at Philadelphia extend back to 1825. Charting these precipitations gives a wave-like curve descending very low in 1825, but with its sinuosities all well above that point until 1881, when the minimum precipitation of 29.57 inches in 1825 was again closely approached. The 1881 fall was 30.21 inches. The years of maximum precipitation were 1841 and 1867. The cycle of extreme low precipitation had a longer period than that of extreme high—56 years against 26 years.

Taking a total period of 64 years, and averaging the annual rainfall by periods of four, eight, sixteen and thirty-two years, the averages by four years run from 22 per cent. low to 19 per cent. high, as compared with the entire period of 64 years. The eight-year grouping gave results from 11 per cent. low to 11 per cent. high; the sixteen-year groups, 6 per cent. low to 9 per cent. high, and the thirty-two-year 2 per cent. low to 2 per cent. high.

LOS ANGELES RAINFALL.

Analyzing the recorded rainfall at Los Angeles for the past twenty-seven years, and averaging by periods of five years, gives results rang-

ing from 35 per cent. below to 16 per cent. above the average seasonal rainfall of 16.56 inches for the entire 27 years. The extreme low points of the Los Angeles precipitation curve are situated 22 years apart, being 4.49 inches for the season 1876-77, and 5.6 inches for the present season up to date. (June, 1899.)

The fluctuation to which the average annual rainfall is subject was very exhaustively considered by Mr. Binnie, M. Inst. C. E., in a paper read before the Institution of Civil Engineers, London, in 1892.

From a close analysis of records of forty-two stations at various parts of the world, covering periods of from 50 to 97 years, he drew the following conclusions:

That, for records of five years, the probable error in averages ranged from minus 16 per cent. to plus 17.6 per cent., falling as the length of the period was increased to about minus 2 per cent. and plus 2 per cent. for periods of 30 years and more. And that: The least number of years the records of which would give an average annual rainfall that would not be materially altered by extending the record, would be thirty-five years. He also concluded that dependence could be placed on any good record of that duration to give an average rainfall correct within 2 per cent.

UNCERTAINTY OF RAINFALL RECORDS.

These examples have been presented to illustrate the uncertainty attached to any deduction based on rainfall records of short duration. As a case directly to the point, we have the French observations, made about 50 to 75 miles south of Paris. The observations of one year gave the precipitation over woods as 33 per cent. in excess of that over open ground. Three years continuous observation changed this to 2 per cent.

Long records for forest purposes are rare. This necessity for long records is but one of the many obstacles in the way of arriving at absolute comparisons of the relative precipitation over woods and open ground. And after sufficient time shall have elapsed to reduce this difficulty to a minimum, there will still remain the errors inherent to measuring rainfall. There is great difficulty in obtaining two locations, the one covered with woods and the other bare, that are subject to precisely the same conditions. Again, the rain gauges themselves are not instruments of precision, and no conclusions can be more accurate than the data upon which they are based. In scientific work it is very necessary to fully realize and attribute a true value to data. Rain

gauges record all that falls actually within them, but, except in very still weather and with gentle rains, they do not intercept all that they should. The wind sweeping across them carries away a portion of the precipitation, varying from ¼ to 7 per cent. for protected gauges, and from 7 to 40 per cent. for unprotected gauges. The decrease in catch of rain gauges raised above the ground, formerly believed to have been due to height, has now been shown to be due to the increased force of the wind. Some very interesting data on this subject has been published by the United States Department of Agricuiture. It also appears that the deficit during gentie, fine rains is very much greater, according to the strength of the winds prevailing at the time, than during heavy rains. There was from 18 to 52 per cent. shortage during fine rains, and 6 to 17 per cent. during heavy rains. The standard for comparison being what is known as the "pit gauge" at ground level. That the loss should vary with the strength of the wind is readily explained. Draw a diagram of forces, the perpendicular representing the downward force of the rain drops, the horizontal the force of the wind in its sweep across the rim of the gauge. It is obvious that the resultant will deviate more and more from the vertical as the rain movement is light and the wind strong.

OTHER ELEMENTS OF UNCERTAINTY.

There is still a greater element of uncertainty, viz:. the smallness of the actual collecting area of a gauge and the comparative immensity of area of country to which its readings are applied. If to every four square miles there was a 10-inch gauge, and this is much closer than we find them, the ratio of areas would be as about 200 million to 1. At Rothamsted, in England, they have a rain gauge measuring 7.26 feet by 6 feet, giving an area of 43.56 square feet on exactly one thousandth ct an acre. The catch on this gauge from 1853 to 1880, twenty-eight years, was about 9.8 per cent. more than the catch in an adjacent 5-inch gauge. The ratio of their respective catchment areas is as 320 to 1. Now, if this ratio of area gave a variation of nearly 10 per cent. in the catch, we must not rely too implicitly on the results shown by applying the readings of a gauge to an area of country several hundred million times the area of the gauge.

All the various difficulties considered we are not warranted in hoping for any decisive direct quantative comparison between the rainfall over forests and open ground. However, while lacking in this direct proof we do know from the records of the various forest stations

that woods reduce temperature and increase the absolute and relative humidity of the air, and, therefore, must to some extent increase precipitation.

EFFECTS OF FOLIAGE ON MOISTURE.

The efficiency of foliage in mechanically arresting and condensing moisture is well known to everyone who has pushed through the brush on a misty morning, or watched the steady drip from the trees during a fog in the lowlands, or during clouds in the mountains.

A notable instance of this feature of vegetation is seen at Ascension, a volcanic island lying about eight degrees south of the equator and nearly midway between Africa and South America. The island is about 30 to 40 square miles in area. It is used as a naval station by the British government. The water supply is obtained from near the top of Green mountain, at an elevation of about 2,800 feet above sea level. The mountain gets its name from being about the only green spot on the island. Its verdure is maintained by the nearly constant drip from trees and rocks of the moisture mechanically collected from clouds and fogs, and light, passing showers. It is this drip which is chiefly instrumental in maintaining the ground-storage upon which the water supply of the station depends.

That the drip from trees should play a prominent part in a domestic water supply is remarkable testimony to the efficiency of woods in mechanically increasing precipitation. It illustrates beyond any peradventure that trees and brush, in situations of cloud and fog, have a decided value as agents for adding moisture to the soil. Interesting experiments have been made as to the amount of concentration of aqueous vapor by leaves, but it is probable that these experiments, made on detached leaves, did not include the effect of air currents. We know that in evaporation a rapid movement of the air is found to contribute very materially to the rate of evaporation by bringing fresh surfaces into contact. Similarly, air movement must materially augment the rate of mechanical condensation. (In the more modern formula for computing evaporation, wind velocity is always a factor.) Cloud or fog is a manifestation of water in suspension, and it is obvious that the more rapidly the cloud is moved against any surface the more water will be brought into contact with that surface in a given interval of time. We all know the wetting through capacity of a mist on a driving wind. Unless the condensation tests were conducted with reference to velocity, they would fail to give full value to the condensing action.

It is questionable whether a numerical value can ever be satisfactorily established for the action of forests in direct increase of rainfall, but it is believed that sufficient has been advanced in the foregoing to show beyond doubt that they do have an effect in that direction, the matter of uncertainty being the question as to quantity only.

CONSERVANCY OF FORESTS.

In the matter of conservancy of the water that has fallen, forests play a very important part. They intercept the sun and rain, and save the earth from packing hard under the baking of the one and the persistent beating of the other. They appreciably decrease the quantity that would otherwise pass rapidly off into the runs and waterways, and be lost in floods. Not only do they lessen the wasteful and destructive expenditure of water in floods, but they afford greater time for the earth to absorb to its full capacity the water held back by the mechanical obstructions of the forest floor. They reduce the quantity lost by evaporation. These things we enter on the credit side of the forest account, and on the debit side make the sole entry of the water used in supporting plant life. It remains to ascribe values to these various items, and strike a balance.

The effect of sun and rain in producing a hard ground surface that sheds water like a roof is known to us all, and we equally know how the broken surface of a ploughed field absorbs rain. The condition of the ground surface is of first importance, and it is here that forests exercise one of their most beneficent functions, a quality which in itself is more than sufficient to justify our constant exertion in preserving and extending our wooded areas. All permanent water supplies are drawn directly or indirectly from the rainfall absorbed and stored within the earth. Directly in the shape of wells, tunnels and infiltration pipes. Indirectly through the medium of running surface streams, which in turn draw their supply from visible springs and the unseen accretions that come in along their beds from ground-water at higher elevation. The surface water which flows into the streams after rains gives but a temporary supply. The permanent flow comes from ground-storage. It must not be thought from this that all ground-water reappears at some time or other in the surface streams. Much passes on unseen to the sea. Its place of discharge into the ocean is sometimes well marked. Off the east coast of England there is a submarine valley, called the Silver Pit, twenty miles long and 50 to 250 feet in depth below the adjoining bed of the sea. The extraordinary

depth precludes it being due to currents, and from the circumstance of the depression occupying, as it were, the focus of the concave chalk formation of eastern England, it is believed to be the point at which the inland ground-waters are discharged through the chalk. Right at home we have a submarine valley of great depth heading near Redondo, with an oil well discharging, about two miles from the shore. The direction in which the ground-water flows is sometimes very difficult to trace. It does not always follow the trend of the surface configuration. Latham, the noted sanitary engineer, in some of his investigations, found the ground-water of a valley passing partly straight down the valley and part turning, going under the hills and coming out on the further slope.

The capacity of the earth to receive and convey water is all-important to us. The large sums that have been expended in damming valleys and impounding water, the legislature that has been invoked regarding reservoir sites, and the extent of agricultural interests dependent on reservoirs, all give evidence of the appreciation of a store of water.

The pervious rocks, gravels and soils of the earth afford a time-tried storage, beside which the largest surface reservoirs are small affairs. The rain is the source and the earth the grand storehouse of our water supplies. Whatever agencies give the rain freer access to the earth should be well studied. As previously stated, the condition cf the ground surface is of primary importance. All soils are dependent upon their top surface as to whether they will get any water to absorb or not. Take an extreme case: Sand covered by an asphalt pavement; a great capacity for water, but no mouth to take it in. Take an ordinary case, as exemplified by tests made at Colby, Kansas, by the United States Department of Agriculture. The moisture in the soil was measured at a depth of twelve inches below the surface. Measurements were made under three separate conditions: First, a covering of natural prairie sod; secondly, bare soil, cultivated; thirdly, bare ground sub-soiled. The tests were continued daily throughout the months of June, July, August and September. The cultivated soils showed throughout the tests over twice the moisture of the soil under the natural prairie top. It has been suggested that the chief cause of the difference was the water taken up and evaporated by the grasses. This is not supported by the records. It is obvious that there would be little moisture drawn from the ground and evaporated during rains. The increase of soil moisture at such times must represent the evapo-

ration saved, plus the rain penetration. This increase amounted to 3.4 per cent., with a rainfall of over 1½ inches. The average difference between the sod cover and the cultivated soil was 10¼ per cent. more moisture in the latter. Now, as penetration and evaporation taken together amounted to only one-third of this difference, it is very certain that evaporation alone could only explain a very small portion of the difference. In fact, it is of interest to note that evaporation may not have reduced the percentage of moisture at all. This would be the case if capillary action was sufficiently active to bring up all tne water needed by the grasses, and there was plently of sub-water to be brought up—conditions that seem to have existed during the test. If the supply is good, a pipe does not show less waste because the faucet at the end is open.

At Rothamsted, the place previously spoken of, there are drain gauges for observing the proportion of rainfall that percolates through the soil. Determinations are made of the quantity passing at depths of 20, 40 and 60 inches. The 20 and 60 inch gauges are in similar soils. The 40-inch is in sub-soil of more gravelly nature, and yields from 2½ to 5 per cent. more water than either of the other two. Observations conducted for twenty years show that an average of 47½ per cent. of all the rainfall percolated through 20 inches of soil, and 44.9 through 60 inches. The rainfall was measured on the 1-1000th of an acre gauge.

As the Rothamsted records are classic in the literature of rainfall and percolation, a description of the gauges used may be found interesting.

The funnel portion of the one-thousandth of on acre gauge is constructed of wood lined with lead, the upper edge consisting of a vertical rim of plate glass beveled outward. The rain is conducted by a tube into a galvanized iron cylinder, and when this is full it overflows into a second cylinder, and so on into a third and fourth and finally into an iron tank. Each of the four cylinders holds rain corresponding to ½ an inch of depth, and the tank an amount equal to 2 inches. Each cylinder has a gauge-tube attached graduated to read to two-thousandths of an inch and by estimation to one-thousandth. Smaller quantities are transferred to a smaller cylinder with a gauge-tube graduated to one-thousandths.

The three drain gauges were constructed by digging a deep trench along the front, gradually undermining at the required depth and put-

12 ting in perforated cast-iron plates to support the mass of soil. The

plates were kept in place by iron girders and the edges of the plates and ends of the girders supported by brickwork on the back and two sides. Trenches were then dug around the block of soil and it was gradually enclosed by walls of brick laid in cement. Below the perforated iron bottom a zinc funnel was finally fixed, and the drainage water collected and measured in galvanized iron cylinders with gauge-tubes as in the case of the rain-gauge.

These soil drain-gauges being kept free from vegetation give results not directly applicable for etimating the percolation over a drainage area more or less covered with vegetation—conditions for which due allowance is made in applying the results.

The capacity of sand for receiving and transmitting water can be well illustrated by the water supply of The Hague, the capital of the Netherlands. The city is situated about two miles inland from the North Sea, and has a population of about 190,000. Its domestic water supply is drawn from a tract of uncultivated country lying near the sea and covered with sand dunes like parts of the New Jersey coast. The sand is described as very pure and white. The water is fresh to a depth of sixty-six feet below the sea. It is gathered by infiltration pipes and pumped to its destination. Through the courtesy of Mr. Corey, the United States consul at Amsterdam, I have been able to make a comparison between the rainfall and the percolating water in point of quantity. The average rainfall from 1878 to 1898 was 30 96-100 inches per annum, of which about 40 per cent. is estimated as percolating.

According to other information, from 30 to 50 per cent. of the rainfall can be collected. The variation being principally due to the seasons in which the rains fall. In summer a loss is stated to take place by reason of vegetation. This draws attention to the point that whether vegetation conserves moisture or not depends very much on the nature of the soil. In the case of sand it impedes the ingress and aids the abstraction of moisture. A sieve would profit nothing as a sieve by planting trees over it.

CONDUCTIVITY OF FORESTS.

The water conductivity and capacity of various soils has received much attention at the hands of forest experimenters.

By conductivity is meant the capacity to transmit water. It involves three units: Quantity, distance and time.

By capacity we understand the quantity of water that a given vol-

ume of soil can be caused to receive into its interstitial spaces, generally spoken of as its voids. Of the volume that can be introduced into dry soils a portion is susceptible of being removed by drainage, and the remainder, held within the capillaries and as films on the grain surfaces, is removable by processes of evaporation only.

It requires no effort of thought to comprehend that conductivity is an important factor in storm run-off, and in estimating the probable yield of a ground storage. The literature of the subject is scant and unsatisfactory. A splendid field is open here for systematic experiment. Such records of experiments that I have been able to obtain indicate that the tests were made by downward filtration. In my own tests I have found it practically impossible to get uniform results by this method. There is always a conflict between the ingoing water and the outgoing air it has displaced. Very uniform results were obtained by reversing the method and filtering upwards. It is true that this does not exactly meet the conditions of rain soaking downward, but it is free from any complications arising from imprisoned air, and furnishes an uncomplicated base from which to start. Then we must remember that the horizontal movements of the underground water are greater than the vertical, and the upward filtration method will give true results for these lateral movements.

The texture of the soil is the governing factor as to rate of conductivity. It ranges from well rounded pebbles, through the intermediate stages of sand and loam to clay. A study of the mechanics of the granular soils presents some particularly interesting points. Assume the granules to be all true spheres and assorted by sizes. It can readily be demonstrated that the voids form the same percentage of the total cubical contents whatever may be the diameter of the spheres, and the area of the passage between the spheres bears precisely the same ratio to the area of the circumscribing cross section irrespective of the diameter of the spheres. The closer a soil approximates to spherical grains of uniform size the greater the capacity for water and the larger the percentage of waterways. This is a property of uniformity of size. By mixing many different sizes together in such proportions that each succeeding smaller size enters the interstices of the preceding layer a soil may be made impervious to water save by capillary action. Proper mixtures of gravel and sand make good water-tight dams. This feature of mixture will frequently explain the imperviousness of stream beds in sandy gravel.

To return to the matter of voids and water passages. Although

these have the same percentages of total volumes and areas in grains of uniform size, the rate of the passage of water will be higher the larger the grains. With very minute grains the passages become capillaries entirely, gravitation is overcome. The larger the grains the nearer the flow approaches that of free water acting under gravitation only.

Capillary action is one of surface tensions. Imagine a membrane enclosing each grain and stretched thereon. The tension of this imaginary membrane is analogous to surface tension. It can be demonstrated by very simple mathematical reasoning that the surface tensions increase with decrease of radius—the sharper the curvature the greater the tension. When neighboring interstitial spaces are filled with water to a greater or less degree, surfaces of films of sharper or flatter curvatures are produced. The surfaces are not in equilibrium, and a movement from the flat to the sharp curves takes place and continues until by readjustment of the curves equilibrium is established. This is the nature of capillary action, it takes place in all directions according to the surrounding conditions. Gravity always acts downwards. In soils the conditions are such that capillary action is usually upwards. The limit of the action varies with the texture of the soil. In chalk the limit is not reached at sixteen feet. In sandy soil one and one-half feet has been found to be the extreme. In very open material the limit may be but a few inches.

In further illustration, imagine a tall box filled with soil completely saturated with water—and the bottom of the box be suddenly removed. The water drains away with gradually decreasing speed. At first a stream, and then drops decreasing in frequency. Capillary action is opposing gravity. The topmost spaces are being emptied by water leaving films around each grain. As the depletion continues the films draw closer to the grains, their curvature grows sharper, their tension increases. They exert an increasing upward pull on those below, and these in their turn begin to pull on those below, and so on down the full depth of the box. Presently the chain of films exert together sufficient force to balance the attraction of gravitation. The dropping from the box ceases.

Add more water to the crop—the interstices are re-filled, the films destroyed or flattened in curvature, the surface tension is lessened. The films below lose all or part of their support from those above. The attraction of gravity prevails, the dropping re-commences, changing to a stream if the supply at the top be ample. The speed with

which this takes place depends upon the texture of the soil and the viscocity of the fluid.

In any case the drops that first appear are not part of the water just added. This is one of the many difficulties in the way of accurately measuring the speed of filtration. The quantity that passes in a given time can, of course, be easily measured, ubt the speed in inches per minute, or in any other unit of distance and time, is quite another matter. That is the difficult point. If we knew the area of the passage ways between the grains we could divide the quantity discharged by this area, combine with the time of discharge and arrive at the speed. Unfortunately we cannot measure these passageways—we can measure the cubical voids but not the area of the passageways between the grains.

An instructive experiment, one easily made, is to fill a glass tube or glass sided box with small marbles and pour oil through them. The use of the slow-moving oil in place of water gives time to note the changes in the shapes of the films and in the filling of the interstitial spaces. Coloring the subsequent additions of oil will aid in tracing the movements of the fluid.

The viscosity, or internal friction of water, has been previously alluded to. Experiment shows that it increases with decrease of temperature. If the viscosity at 32 deg. Fahrenheit be assumed as 100, it will be 50 at 77 deg., 45 at 86 deg., and 31 at 112 deg. This variation of viscosity due to temperature has a marked effect upon the rate of percolation. This effect is very important. The following quotation from experiments of the United States Department of Agriculture will serve to illustrate and emphasize the point:

Flow at 48 deg. Fah., 6.15 grams per minute. Flow at 90 deg. Fah., 10.54 grams per minute. The ratio of the two rates of flow being as 100 to 171. Now the viscosity of water at 48 deg. Fah. is to the viscosity at 90 deg. Fah. as 75.6 is to 32.5, or as 177 to 100. The flow should be in the inverse ratio, and this agrees very closely with the ratios of the actually measured flows.

The viscosity of gases, contrary to that of fluids, increases with increase of temperature. Air is frequently used in making "permeability" tests of soils, and unless corrections are properly made for this different characteristic very erroneous and misleading results will ensue.

Speaking of air as a means of testing permeability of soils recalls an instance in connection with coal mining. Water broke into

the workings of a mine and, as it rose, imprisoned air in some of the mine chambers. The rising water forced this air through the rock in several places—failing to do so at other points. A hydraulic head of forty feet forced the air through two hundred feet of solid coal and the water filled the chamber. Upon pumping out the water it took the air two weeks to find its way back through the two hundred feet of coal and fully destroy the vacuum made by the falling water. On the other hand, slate—with its laminations lying at right angles to the pressure—was perfectly tight and retained the air against a hydraulic head of eighty feet.

Tests at the German forest stations show that the general effect of forests is to raise the soil temperature during the cold months and lower it during the warm months. As the bulk og rain falls in the cooler months, it follows that the raising of temperature during such times is favorable to increased percolation by reducing the viscosity of the water. A portion of this advantage would be offset by lowering temperatures during the hot months. The surface tension of water is also lowered by increase of temperature, as well as the viscosity. This decreases the tension in the capillaries, causing less resistance to gravitation, and more water passes down on this account.

The following percolating velocities are quoted in the publications of the agricultural experiment station of the State of Colorado. They were deduced by the Italian Professor Nazzini from data obtained from the filter beds of London, Paris and Berlin. They will serve to illustrate the variation of velocity due to texture of material. The velocities refer to that of vertical filtration:

Minute gravel........................	86 1-2 feet per hour.
Coarse sand........................	9 1-3 feet per hour.
Fine sand...........................	1 7-10 feet per hour.
Sandy soil...........................	8-10 feet per hour.
Sandy clay..........................	4-10 feet per hour.

These figures cannot, however, be taken as proper for universal application. Each soil is more or less a law unto itself, and where exact results are sought must be studied by itselt.

There is one great distinction between water flowing freely in open channels or pipes of measured size, and percolating water. The flow of the former is a function of the square root of the head, while water finding its way through minute passages is found to vary in flow directly with the head and not with the square root thereof. The

mathematical demonstration of the reasons for this is interesting, but would scarcely be pertinent at the present time.

Capacity, as previously stated, is the quantity of water which can be introduced into a dry soil. It is usually expressed as a percentage of the soil volume. The total quantity that a soil is capable of imbibing is termed its maximum capacity. This quantity is divisible into two parts. The one removable by drainage, the other by evaporation. The latter is again sub-divisible into two parts. One part is brought to the surface by capillary action and there evaporated, the other is almost permanently retained within the soil, requiring for its removal long continued application of heat. This is termed hygroscopic moisture.

From German authorities we have the following maximum capacities of various soils, expressed in percentages of volume:

Humus	70.3 per cent.
Garden mold	69 per cent.
Peat	63.7 per cent.
Loam	60.1 per cent.
Lime	54.9 per cent.
Chalk	49.5 per cent.
Quartz sand	46.4 per cent.

For minimum water capacity, or water remaining after gravitation, we have—varying according to depth—

Humus, loose	43.6 to 49.1 per cent.
Loam, fine, loose	38.4 to 48.3 per cent.
Sand, loose	17.6 to 27 per cent

The hygroscopic moisture was determined by Loughridge, of the California experiment station, to be as follows:

Clays	from 2.6 to 14.5 per cent.
Loams	from 4.9 to 9.2 per cent.
Sandy soils	from .8 to 3.5 per cent.

The wide range in these figures serves to illustrate the necessity of experimenting directly with the soil itself, if exact data is required of any particular soil.

The precise nature and mechanics of hygroscopic moisture are but little understood. There is a good field here for independent investigation.

Of the different capacities the hydraulic engineer is more particularly interested in that which relates to the quantity that may be drained out; on the other hand, the aboriculturist is most inter-

ested in the amount of capillary water from which plant life largely draws its supply. The capacities are interwoven and the experimental determination of the moisture coefficients of local soils will be a fruitful field for forestry students. To return to capacities. An authority on effects of forest cover (Dr. E. Ebermayer) found that except for the top layers unshaded soil had more capacity than shaded soil. Taken as a whole, however, for a depth of thirty-two inches he found the soil under young spruce trees to have 2 per cent., and under old spruce trees 7.6 per cent. greater capacity than naked soil.

It is manifest that the character of the forest floor, the litter covering the soil, must have a marked effect upon the absorption of water. Wollny found, as a result of his experiments, that under a grass cover there was 50 per cent. less percolation than in naked soil. He found a litter of oak leaves to pass 42 to 74 per cent. of the rainfall. Spruce litter passed 46 to 78 per cent. Pine needles, 52 to 69 per cent. Moss, 39 to 53 per cent. The variations are due to varying thicknesses of cover. The shallower the cover the less the soil received. This may be attributed to greater rate of evaporation with the shallower covers.

As previously stated, the Rothamsted tests gave the percolation of bare soil at 44 9-10 to 47 1-2 per cent. of the rainfall. It will be seen, therefore, that ordinary forest litter can pass more rainfall than the earth ordinarily imbibes. Consequently the cover will remain wet for a greater or less period of time, and during that period save the soil from evaporation. A soil covering of humus, however, would scarcely allow any filtration to the soil beneath. It would be beneficial in lessening the force of storm water, but otherwise would work a loss to ground storage.

Ebermayer says that besides clay it is especially humus which imbibes almost all precipitation and gives up little water below; and adds, that if the earth were covered with a humus soil of one metre in depth subterranean drainage would be so slight that springs would be scanty, and continuously flowing springs absent.

The forest floor is a most important factor in retarding storm water and protecting the earth from erosion. This is particularly true on steep mountain slopes. The destruction of forest litter by fire or de-forestation is little short of a calamity. Each rain washes away tons upon tons of loam, sand and rocks to cover up the lower lands. A double disaster. The fertile soil of the higher lands is destroyed, the fertile soil of the lower lands buried.

CHAPTER XXIV.

EVAPORATION.

We have another subject to consider—that is, evaporation. Under this head will be included transpiration from foliage.

On the subject of evaporation there exist many experimental data. Temperature and wind are the chief controlling elements. Woods lower temperature and reduce the velocity of the wind. It is to be expected, therefore, that evaporation in woods is much less than in the open. Such is found to be the case.

The observations of sixteen forestry stations in Germany show a marked saving effected by the woods. Of the rainfall, an average of 42 per cent. was evaporated in the open and 24 per cent. in the forest. A clear saving of 18 per cent. The Prussian stations showed the evaporation under trees to be about 43 per cent. of that from fallow fields; this percentage for the previously mentioned sixteen stations would be 57 per cent. The evaporation from water surfaces in woods was found to be about 38 per cent. of that from water surfaces in the open.

As an offset to the saving in evaporation comes the moisture transpired through the foliage, and that retained in the substance of the tree. The transpiration computed by various observers ranges from an equivalent rainfall of one-fourth inch per annum for four-year old firs, up to fifteen inches for cereals and thirty-seven inches for grasses. Forests of mixed growth transpire about 6½ inches. According to observations at the Austrian stations, deciduous trees transpire during the period of vegetation 500 to 1,000 pounds of water per pound of dry leaves, and the coniferous from 75 to 200 pounds. (This suggests the natural selection of conifers for our mountain slopes.) One remark of Hohnel, regarding the Austrian observatories, is very suggestive. He says "a plant will transpire in proportion to the amount of water which is at its disposal." This remark serves well to mark the point that willows and other water-loving growths along our streams consume more water than they save.

It is estimated that a coniferous forest will transpire 8 per cent. of a total rainfall of 20 inches, and a beach forest 48 per cent of the same precipitation. The water annually absorbed into the structure of the trees has been estimated as ranging from 19 to 52 per cent. of the weight of the wood, and 54 to 65 per cent. of the weight of the leaves. By the hardwood deciduous trees, 38 to 45 per cent; the softwood, 45 to 55 per cent., and the conifers, 52 to 65 per cent. These

quantities require about 2 per cent. as much water as the water of transpiration and in additioon thereto. On these figures a coniferous forest, which of all the trees makes the best showing, will give a net increase to the ground storage of about 10 per cent. of the rainfall, to say nothing of the storm water held back until the earth has had time to drink its fill—an important item in itself.

As a practical illustration of actually observed results, the following quotations from a report of the State engineer of New Jersey are most appropriate:

"We believe it will be helpful to the cause of forestry in the "future if the effects of forests upon stream-flow are more carefully "and accurately stated.

"Their effect of holding and preserving the soil upon slopes is very "well known, and besides this they create a mass of humus and ab-"sorbent matter upon the surface which has an effect upon stream-"flow, and the general evils resulting from de-forestation are a mat-"ter of careful observation and record, so that too much stress cannot "be laid upon the desirability of preserving a proper area of forest.

"The study of the streams shows that in every case, almost, it "is the watershed on which is the largest proportion of forest which "shows the largest flow from ground water."

This is a very positive statement, but being based upon continuous gaugings of the streams in question, it cannot be controverted.

CHAPTER XXV.

PRACTICAL IRRIGATION.

S. M. Woodbridge, Ph. D.

Irrigation is the artificial watering of the soil for the production of crops.

Although irrigation is looked upon by many as a new proposition, it is, in fact, the most primitive method of producing crops; that is, it is the oldest method, for according to written history, "A river went out of Eden to water the garden." Furthermore, it was the only method of producing crops for the first third of human existence; for, from the same authority above quoted, we read: "The Lord God had not caused it to rain upon the earth." As it appears that water was only distributed through irrigating ditches for the first third of the world's written history, it is not improbable that when Abel took his sheep down to Cain's irrigating ditch to water them, that he made this water business a pretext for "doing up" Abel. The precedent of making trouble over water thus established, has been pretty well followed down to the present time.

The first rain that we have any record of was in the year B. C. 2349, and there has been nothing equal to it since; that rain is commonly known as The Flood. Agnostics think that they have scored a point when they state that the properties of light must have been just the same before the flood as since, and claim that the bow must have existed from the beginning; but they overlook the fact that the whole agricultural business was run on an irrigation plan and that there was no rain previous to the flood.

Water for irrigation purposes is derived from three sources in California.

1. Mountain and other streams.
2. Wells—flowing or pumped.
3. Reservoirs.

Of the above named sources, it would seem that the reservoir is the most important, for every available foot of land can be made a reservoir. In the technical sense a reservoir is "a basin, either natural or artificial, for collecting and retaining water or other liquids."

There are two essentials to make a reservoir a success: First,

there must be means for collecting the water; and second, means for retaining it until it is needed. When we speak of soils and mountains as reservoirs the word is not used in the technical sense, for I believe that the great volume of water that continues to flow from our mountains are held in the interstices of the soil and rocks.

My own investigation shows that our different soils hold from 17 to 26 per cent of water, although some authorities make a much larger percentage.

Different kinds of soils vary in regard to their porosity, and the same soils vary to a very great degree in regard to their absorptive power of water, depending upon the amount of moisture already contained in them. For example, on the red mesa soil at South Pasadena, where the soil was practically dry, containing a little over one per cent. of water when the water was turned on, it only absorbed one-twentieth of the amount of water in a given time that was absorbed by soil of the same kind which contained at the beginning of the experiment about eight per cent. of moisture. This may be an extreme case but it is remarkable how much water will run off from the soil when it is dry. We see the same effect if we dip a dry feather in water, when we pull it out it comes out dry. But if we moisten it, and then dip it in water, it comes out saturated. It seems neccessary then in order to have our land absorb the maximum amount of water in the mininmum amount of time, that the soil should retain a goodly percentage of moisture. Or, in other words, if we wish to fill our mountains and soils with water and preserve the greatest amount of rainfall, they should be kept moist.

Having shown that it is necessary to have some moisture in the soil in order to have it absorb the rainfall readily, and thus make our mountains an arable reservoir, let us look at the other side of the case—that of retaining the moisture; and I regret to say that the experiments are not so complete and numerous as they should be, as they have only been fairly begun.

In the first place let me call attention to the fact that capillary action in soil is in every direction from a given point. Water spreads out sidewise as well as upwards and downwards by this action. Soil that was thoroughly irrigated was taken and the amount of water determined at 26.12 per cent. Some of this soil was put in beakers, filling them about half full and placed in the laboratory. On the following day 66 per cent. of the moisture had dried out. Tin cans without either bottoms or tops were pressed down into the soil and

the soil taken from the side of the can so that a slide could be passed under it, thus cutting off connection from the earth beneath. It was found that about the same amount of water had disappeared from these cans as had disappeared from the beakers. Where these cans had been pressed some inches below the surface of the ground and the soil raked or cultivated above them, there was practically little loss of moisture. Conclusions from these facts are very obvious, that in order to make reservoirs of our mountains and arable lands it is necessary to keep them in such a condition that they will readily absorb water and retain it, and this result can be brought about only by keeping them covered with the product of growh, or in other words, with forests, as these forests and their products make a covering or mulch for retaining moisture. And the same reasoning pertains to our cultivated lands, that in order to retain the moisture we must keep them well cultivated.

MEASUREMENT OF WATER.

It is a pity that there is no uniform unit of measure upon the metric system for stating a definite amount of water.

We are at present compelled to use the arbitrary and often puzzling term of acre foot or inch, second foot, weir inch and miner's inch. An acre foot of water is the amount of water that will cover an acre of ground one foot in depth. A second foot is a cubic foot of water per second. A miner's inch of water is the amount of water that will flow through an inch square hole in an inch board under a pressure of four inches in twenty-four hours; such an amount of water has been determined legally to be 12,960 gallons.

I would venture to suggest that the miner's inch, having been legally established to be a definite amount of water, be used as the universal unit of measure in irrigation matters, and the following table based upon the French decimal or metric system be used in conjunction therewith. The Greek prefixes being used to denote the multiples and the Latin prefixes the fractional parts of the unit.

The Greek prefix "DEKA" to mean 10 units.

The Greek prefix "HECTO" to mean 100 units.

The Greek prefix "KILO" to mean 1000 units.

The Greek prefix "MYRIA" to mean 10,000 units.

The Latin prefix "DECI" to mean 1-10 of a unit.

The Latin prefix "CENTI" to mean 1-100 of a unit.

The Latin prefix "MILLI" to mean 1-1000 of a unit.

Proposed table for the measurement of irrigation water:

1 Myria-inch-	10 Kilo-inches	10,000 inches
1 Kilo-inch	10 Hecto-inches	1,000 inches
1 Hecto-inch	10 Deka-inches	100 inches
1 Deka-inch	10 inches	10 inches
1 Inch	10 Deci-inches	1 inch
1 Deci-inch	10 Centi-inches	1-10 inch
1 Centi-inch	10 Milli-inches	1-100 inch
1 Milli-inch		1-1000 inch

TABLES OF EQUIVALENTS.

1 Myria-inch	129,000,000	gallons
1 Kilo-inch	12,960,000	gallons
1 Hecto-inch	1,296,000	gallons
1 Deka-inch	129,600	gallons
1 inch	12,960	gallons
1 Deci-inch	1,296	gallons
1 Centi-inch	129.60	gallons
1 Milli-inch	12.96	gallons

Water is contained in the soil in three different states, as:

1. Hydroscopic water.
2. Capillary water, and
3. Water of percolation.

Hydroscopic water is that which is not perceptible to the senses, but is appreciated by a loss or gain of weight in the soil which acquires or is deprived of it.

Capillary water is that which is held in the fine pores of the soil by the surface attraction of its particles.

Water of percolation is that which fills the interstices in the soil and would percolate through or filter out from the soil.

An acre of ground contains 43,460 square feet; allow 100 pounds per cubic foot of dry soil, we would have 4,356,000 pounds every foot in depth. Let us make a reasonable assumption as to the reservoir capacity of our soils. They will hold as hydroscopic and capilliary water about 20 per cent. of their weight. Assuming that our soils are only wet to a depth of ten feet in the rainy season, we would have 8,712,000 pounds of water stored in each acre of ground, or more than ten times the amount of water necessary to raise 20,000 pounds of oranges per acre, if all the water was available, which it is not.

Professor King has estimated that it takes to raise different crops, such as hay, barley, clover, etc., from 300 to 500 tons of water to make one ton of dry matter. My investigations lead me to think that it takes much less to raise fruit, about 200 tons of water to raise

one ton of oranges or lemons; now, allowing 20,000 pounds of fruit per acre, let us see how far one inch of water would take us. Oranges contain in round numbers 18 per cent. of solid matter and 82 per cent. of water, therefore, 20,000 pounds of fruit would contain 3,600 pounds of dry matter; if we multiply this factor by 200, the number of pounds of water it takes to raise one pound of dry fruit, and with this result, namely, 720,000, divide the total number of pounds in an annual inch of water, we would get 54.5, which would represent the number of acres of oranges producing 20,000 pounds of fruit per acre, that one inch perpetual flow would supply, making no allowance for water put into the ground by winter rains.

SURFACE IRRIGATION.

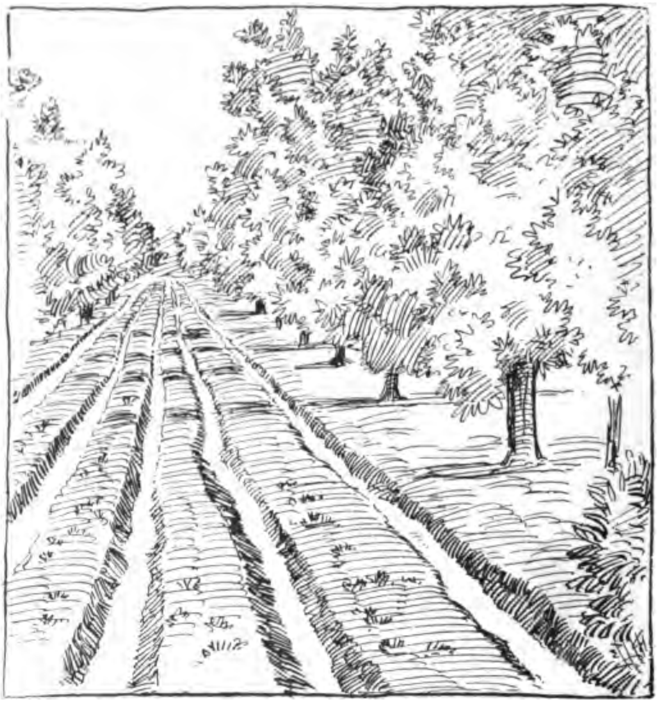
There are four systems of surface irrigation in general use in Southern California. The first method is a basin method where they cover the whole of the ground; a double furrow runs down between every other row of trees, the furrow large enough to carry from fifteen to fifty inches of water. Let us trace this stream, starting from the head ditch. The attendant breaks down the furrow enough to let all the stream flow into the first basin, requiring from one to three minutes to fill it according to the size of stream and basin, every other tree is irrigated until the last tree is reached, when the attendant works back, irrigating the trees he omitted on his downward course; thus when the last tree is irrigated in both rows, the attendant is back at the head ditch, where he can quickly turn the stream between other rows without loss of time. The cost of making these basins is variously estimated from $1.50 to $2.50 per acre.

The second method is also a basin method, the basins covering the whole of the ground but without furrows. The water is run into the first basin until it is filled; when a portion of the lower side is broken down and the water allowed to flow into the next basin; and so on down through the whole row. When the last basin is filled and while the water is still running, the attendant goes back to the head ditch and turns the water into the next row of basins.

The third method is where the basins are made only over a portion of the ground, thus omitting to irrigate a part of the land.

The fourth method is called the "Modern Method." It consists in having a head ditch at the highest side of the orchard and running the water down through small furrows to the lower end. The number of furrows used varies from one to eight. It is an easy, convenient and cheap method.

Inasmuch as the roots of trees in an orchard form a perfect network through the whole soil, it is necessary to get an even distribution of the required amount of water over the whole of the land, i. e., where surface irrigation is resorted to. This certainly can be done by the basin method first above mentioned. This method, al-



THE MODERN METHOD—SURFACE IRRIGATION

though perhaps the oldest in use, finds many objectors, who say it is impracticable, expensive, and even impossible in some instances. There are those who maintain that it washes the ground too much, and that where the ground is rolling and the basins have to be made small, too much expense is incurred. The third method is to be condemned in every instance. For as has been observed, the roots of trees form a perfect network throughout the soil and these roots are feeders. If, therefore, the roots which have grown during the rainy season into the unirrigated portion are left without water and the soil becomes dry, they languish and die. The fourth method called the "Modern Method," should never be resorted to except where ab-

solutely necessary, and then the head ditches should be very near together and the furrows small and numerous. This method is very easy, popular and cheap, and what is more the pity, many people are in the habit of so irrigating.

The different methods seem to be persistently followed in different localities in the state.

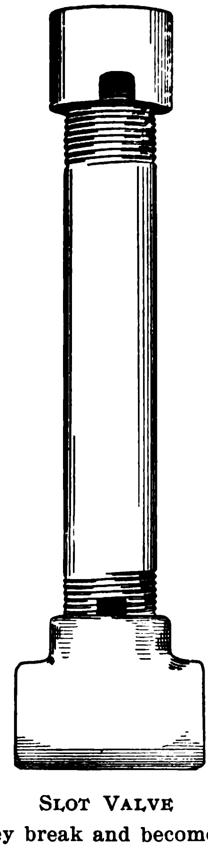
Where surface irrigation is practiced and where the ground is kept cultivated to the depth of six inches, it follows from the premises, that from one-half to two-thirds of the water (allowing one miner's inch continuous flow to ten acres of ground) is wasted—for the portion of the water which is soaked up by the cultivated ground is lost to the tree, for in the cultivation the moisture in the cultivated soil goes off in the air. To save this immense proportion of water, it follows then as a natural sequence that the water must be placed below the cultivated ground, i. e., sub-irrigation must be resorted to.

SUB-IRRIGATION

Has always given satisfactory results as to a proper distribution of water, but no system heretofore has been satisfactory from a practical and economic standpoint, owing to the fact that the pipes have become broken or filled with roots and clogged; no underground valve having been invented that was economical and at the same time tight and impervious to roots. We have tried and can recommend as an absolute and almost perfect system of sub-irrigation, that an orchard be piped between each row, with one inch iron pipe at the depth of about 18 inches from the surface, and that in the center of the square formed by four trees, a hydrant be placed, as appears in the cut herewith. This is a very cheap and simple device. It consists of nothing but a short piece of pipe with an extra number of threads on one end, say seven or eight; there are two slots cut down through a portion of the threads; this pipe is screwed down into a tee in the main pipe. To start the flow of water, this pipe with slots in it is partially unscrewed, which permits the water to run out through the slots. Anything that would grow through the slots is effectively cut when the water is turned off by screwing down the pipe. A depression about four inches deep and three inches in diameter is left around each hydrant and the water is turned on sufficiently when it appears at the bottom of this depression. Rev. C. F. Loop has such a system of sub-irrigation at Claremont, except that the valves are much more expensive, costing about 35 cents each. Dr. Loop says that the system has given him perfect satisfaction, and he is of the

opinion that he does not use half the amount of water that he formerly used, and that he saves more than half the expense ordinarily incurred in cultivation, etc.

Other systems have been invented, and some patented, but all, so far as known to the writer, have proved failures. From the best information that can be gathered, all cement systems have proved failures; although when first put in use, they did the work designed for them with satisfaction. Cement pipes have not proved a success



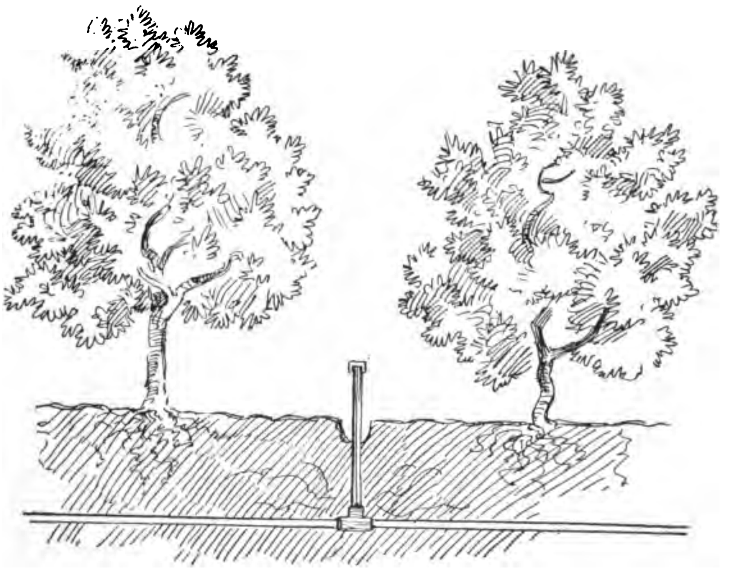
SLOT VALVE

owing to the fact that they break and become leaky, necessitating constant repairs. And they also become filled with roots.

Experiments with cement pipes were begun in California about twenty-five years ago, and have continued to the present time, and yet the writer does not know of a single orchard, nor can he get

any trace of one, that is being irrigated now by such a system that has been in existence five years.

Mr. Jas. Campbell, of Pasadena, tried a system of sub-irrigation in two and one-half acres of orange orchard some twelve or fifteen years ago, with three-inch continuous cement pipes laid twenty inches deep. He says the system worked with perfect satisfaction for three or four years, which was as long as the pipe kept in good order. He does not think that he used one-third the amount of water that he did by surface irrigation. Indeed, he could not have used as much as one-third, for he states that the reservoir from which he irrigated his two and one-half acres contained but 10,000 gallons of water, which would only be at the rate of 4,000 gallons per acre per irrigation; allowing two irrigations per month, it would only be 8,000 gallons per acre, or equivalent to one miner's inch continuous flow to about 48



SUB-IRRIGATION

acres. He also says that the labor for cultivation was much less than in orchards irrigated by the surface method.

There are several patented systems, which require the underground discharge to be surrounded with coarse stones or gravel, or both, and even with cement flagging under the outlet; but all these only increase labor and expense to a system without any corresponding good to be

gained thereby. Elaborate tests in actual practice have shown that the water will seep out in the same length of time a radius of ten feet from a valve buried in the ground, or from a mere post hole three inches in diameter, or from a hole that is one foot in diameter, or from one that is two feet in diameter. This may seem a strange statement, yet if we will consider that the contents of a circle twenty feet in diameter contains 314 square feet, and that by making a hole two feet in diameter, we would only take away 3.14 feet, or about one per cent of the soil within the larger circle, it is apparent that little is saved in point of time by making a large hole to be filled up with extraneous and perhaps expensive material.

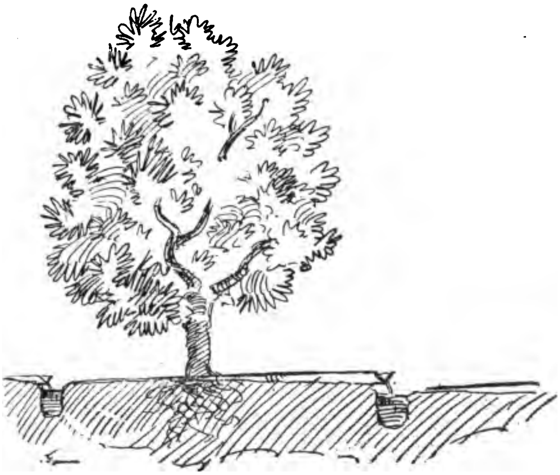
As the cost of such a system as is recommended above would be about $100 per acre, it still puts the system beyond the reach of most of the ranchers, although the annual saving would be about 15 per cent on this investment in labor, etc., without any reference to saving the water. It is also impracticable where the water is distributed in open ditches. as it requires some little pressure in order to distribute the water through an inch pipe. Other means less expensive were therefore tried, one of which has been quite successful. This system is called.

INTER-IRRIGATION.

It consists in distributing the water above ground but in disseminating it below the surface. This is done by means of holes the width of an ordinary shovel dug to the depth of from 16 to 24 inches, according to the nature of the soil, in the center of each square formed by four trees. On ground that is level or nearly so, a single furrow is run down a little to the side of these holes; a furrow at right angles from that furrow is dug to run in and fill up the hole, which is kept full during the period of irrigation. The water then passes on down the furrows and into the next hole, and so on to the last hole in the orchard. Where the water can be run down diagonally through an orchard, or if the orchard is set quincunx, there need be but one furrow in every other row. Where the ground is rolling, or on side hills, it will be necessary to have wooden or other troughs or a system of movable pipes to keep the ground from washing, and it is always best to have troughs or pipes. The troughs in use at Lenapuente are made from wooden strips 1x2 nailed on 1x3, making a V-shaped trough. No joists are required as a single length is run from hole to hole. The cost of such troughs is about $18 per acre where they run on the squares, or $12 per acre where they are run every other row diagonally. The pipes used at Lenapuente, where the water is delivered under

pressure, are one-half inch iron with a valve, such as is above described, over each hole. The pipes are connected and disconnected by means of a Wilgus union. Both troughs and pipes can be easily transferred from one portion of an orchard to another.

As to the objections to the system, there are apparently but two. The first and most important objection is the difficulty of getting a sufficiently long run of water to be able to irrigate in this manner; for it takes from two to four times as long, according to the nature of the soil, to irrigate by it.



INTER-IRRIGATION

We think this objection would in practice amount to little or nothing, if a community should adopt the system. If the existence of an orchard depends upon it, or the successful maturing of a crop, we apprehend that arrangements could be made for giving the individual rancher his water in from two to four times the length of run, cutting him down in quantity correspondingly.

It has been ascertained that soils differ in regard to their porosity and, consequently, in their absorbing power. The extremes seem to be in different soils, that a single hole will soak away from five to fifteen gallons of water per hour, this largely depending upon the amount of moisture that there is in a soil; a perfectly dry soil requiring much more time than the soil containing six to eight per cent of moisture. This must be determined by each rancher for himself. It is done by placing a barrel containing a known quantity of

water, on the ground at the side of the hole with the faucet over it; allowing the hole to be filled with water from the faucet to the desired height, regulating the flow so that the water will stand at this height in the hole. Assume that you desire to soak away 389 gallons in this hole (the equivalent of one miners' inch continuous flow to ten acres where there are 100 trees per acre) and that it took 38.9 hours to soak away the 389 gallons, this would be at the rate of ten gallons per hour; one would then know that such irrigation must continue by this system for 38.9 hours in order to get what would be equivalent to one miners' inch, continuous flow, to ten acres.

And the second objection is, the trouble of cultivation where there are troughs and holes through an orchard. But if the troughs are set deep enough, there is little objection on this hand. The holes form little or no objection. It must be remembered that not one-half the cultivation is necessary as in the other system. Besides there is nothing good in this world without its corresponding evil.

It has been found that orange trees that are twenty years old and upwards, which were wilted, were revived by the application of 200 gallons of water per tree in this way, and remained in a fresh condition for over thirty days. How much less might have answered the purpose will be determined in the future by actual measurement.

The system of sub-irrigation or inter-irrigation is especially adapted to small flower beds and garden purposes generally.

Two modifications of the above described plan for interirrigation have been installed on a number of ranches in Southern California during the past year with the most beneficial results. The first and undoubtedly the best method is conducted as follows: One or two deep furrows, not less than 12 to 14 inches deep, are plowed between each row of trees, parallel to the head ditch, then the irrigating furrows are made at right angles to the flume, but some two or three inches shallower than the cross furrows. The cross furrows are then run over with a single horse shovel opening the connections with the irrigating furrows on one side and closing them at the other side—thus making a pocket in which the water is held during the period of irrigation.

The second method merely consists in making one deep furrow between each row of trees, the furrow being not less than 14 inches deep—made by running a turning plow both ways in it and where necessary running a subsoiler in the bottom of the furrow so made.

CHAPTER XXVI.

IRRIGATION IN THE SOUTHWEST.

By Jas. D. Schuyler, Hydraulic Engineer.

In the arid portion of the United States embracing fully one-half of the entire area, there prevails a climate of such marked healthfulness as to afford a perpetual charm to the pleasure of living. Added to this is an exemption from violent storms, destructive tornadoes, and excessive extremes of temperature. Furthermore, the arid region is usually blessed with soils of great fertility, and a greater proportion of sunny days than other less favored portions of the country. All of these advantages, conducive to health, long life and comfort, are only offset by the one disadvantage of unequal distribution of rainfall, by which the arable lands of the valleys are left with an insufficiency of moisture to mature crops without artificial irrigation, while the mountains alone receive the amount of precipitation which in the east is distributed impartially over mountain and valley as well. The mountains thus become practically the sole feeders of the western streams, and these streams become the main source to supply the lacking moisture required by the valley lands. The wealth and material resources of the country are thus dependent upon irrigation, upon the flow of the streams, and upon the precipitation and run-off from the mounains. Any influence which tends to diminish the power of the mountains to supply water to the streams retards the development of irrigation, and checks the progress of all agriculture, horticulture and their dependent industries. Forest growth upon the mountains is the mother of the springs and streams, and needs to be fostered and maintained at all hazards if the population, which is naturally attracted by the many charms of the arid region, is to continue to grow and increase in wealth.

There are no drawbacks to an irrigated country, provided the water supply of the streams is maintained. Agriculture under a system of

irrigation is really superior in point of convenience, certainty, reliability to that which depends upon the caprice of the summer rainfall for the nourishment of crops. There is every incentive, therefore, for the fullest development of all the water which the mountains will yield and its conversion to useful purposes.

FORMATION OF IRRIGATION DISTRICTS.

The beginning of every irrigation district is naturally made by the construction of canals and the diversion of the flowing streams. At the outset the water so diverted performs a limited duty, as the thirsty lands absorb it greedily, and a large stream will wet but a small proportion of what it will ultimately water when the subsoil becomes saturated and the water plane rises nearer and nearer to the surface with each successive year. Gradually the stream is able to care for more land, cultivation is extended, additional canals are made possible, and the irrigated settlements grow in extent and area of cultivation. Occasionally there will come a season when the rainfall is below the normal, and the run-off of the streams, which in the rainy season may still be abundant, will, in the months of greatest need, be so far short of the usual flow as to cause serious inconvenience and emphasize the need of storage reservoirs. This is the stage of progression which is everywhere reached in course of time. The third stage after the reservoir period is that which implies the development of underground waters by wells and pumps. In some sections of the country where the streams are quite intermittent, and only flow during the rainy season, development must begin with the storage of water. In other sections, where reservoir sites are scarce and dams expensive to build, irrigation begins with wells and pumps, to be followed later by the more costly works. The final stage is that where a water supply can only be obtained by works that are beyond the reach of private capital or individual effort by reason of their magnitude, and where government aid must be invoked. Over a large portion of the arid West it is believed that this stage has been reached, and further progress can only be attained by inaugurating a liberal policy of governmental control and construction of storage reservoirs, and there is a growing sentiment in favor of such a policy.

THE TONTO BASIN RESERVOIR.

In the great Salt River valley of Arizona, the natural stream flow has been utilized in the cultivation of some 250,000 acres of land, whose fertility and productiveness form the basis of the agricultural wealth

Cuyamaca Lake, San Diego County, California. Used for Irrigation.

of that territory. The valley contains a boundless extent of equally valuable desert land, whose only hope of development lies in the construction of reservoirs. The one chiefly relied upon is known as the Tonto Basin, at the junction of Tonto Creek and Salt River, some 80 or 90 miles above the city of Phoenix, the capital of Arizona. A dam is here projected which will impound over 1,000,000 acre-feet, or sufficient water to cover one million acres one foot deep. The tributary watershed area is over 5,800 square miles, from 2,500 to 8,000 feet in altitude, affording an annual run-off sufficient to supply the reservoir. The dam will be constructed of masonry, and will be 250 feet in height, whose length between the solid sandstone walls of the canyon will be 150 feet at base and 650 feet at top. The dam is estimated to cost $1,500,000, and three years' time will be needed to build it. The work has been undertaken by a corporation styled the Hudson Reservoir and Canal Company of New York. The enterprise is one of the most extensive and important ever projected in the arid region, and one of the very few which has a prospect of being profitable to the stockholders, by reason of the fact that the water can be immediately sold at wholesale to a population waiting, with canals already built, for its utilization. The canal system of Salt River valley commands a greater area of unimproved desert land than the water of the unreservoired stream will serve.

RESERVOIRS ON THE GILA RIVER.

The Gila river, above its junction with the Salt, is quite as completely utilized as the latter stream, although the development of irrigation by canals has taken place upon the upper valleys at a much greater rate than in the main valley of the stream. This has resulted in depriving the lower appropriators of their usual supply in the dryer portions of the year, and caused great loss and privation, particularly among the Pima and Maricopa Indians on the Sacaton reservation. As these peaceful and industrious tribes are the wards of the government, an effort is being made to restore their water supply and furnish their parched fields with the needed element, by impounding the flood waters of the Gila in a mammoth reservoir. To this end the United States Geological Survey has been charged with the task of investigating the various available sites to determine where a dam can be most advantageously constructed. Borings have been made at the Buttes, some fifteen miles above Florence, at Riverside, fifteen miles higher up and at the western end of the San Carlos reservation, where the Gila

breaks through a high mountain range in a narrow canyon. The latter site has proven most favorable, not only on account of the superior character of the rock available for construction, but because the bedrock is nearer the surface, and the canyon walls are but 100 feet apart at the stream level. The reservoir capacity of the dam is very great, and with a dam 150 feet high the water impounded would exceed 360,000 acre-feet. This volume would not only amply supply the Sacaton Indian reservation below, and render the Indians self-supporting, but it would supply the white settlers above Florence, and open a large area of desert government land to occupation and settlement.

These two reservoirs, when completed, will more than double the present productive area of the territory, and their importance to the nation cannot well be over-estimated.

RESERVOIRS ON THE RIO GRANDE.

The Rio Grande, which heads in Colorado and passes through New Mexico and along the Texas border on its way to the gulf, has reached the stage where reservoirs are required to promote further irrigation possibilities. Increasing diversion of its upper waters, as in the Gila valley, has deprived the lower appropriators of their customary supply. To meet this condition, one of the greatest reservoirs of the Southwest has been projected by an English company at Elephant Butte, 112 miles above El Paso. A masonry dam is to be built at this point which is to be 100 feet high, 300 feet long at base, 550 feet at top, and impound 253,000 acre-feet of water. The flood waters passing this point range from 500,000 to 2,200,000 acre-feet annually, the greater portion flowing off in May and June, while in August and September the stream is frequently entirely dry. The construction of the reservoir will permit of the irrigation of 250,000 acres of new land, and afford a reliable supply to 100,000 acres more that now receive such a precarious and uncertain volume as to be of little permanent value. The dam and the 200 miles of canal involved in this enterprise are estimated to cost $850,000—an insignificant sum in proportion to the enormous addition which the works will make to the material resources of New Mexico and Texas.

Immediately above the Elephant Butte reservoir is another site, where a dam 80 feet high will impound 175,000 acre-feet of water. These reservoirs are only second in importance to those of Arizona, just described.

Proposed Dam Site of Vast Storage Capacity, Toulumne River, Sierra Nevada.

The Pecos is one of the principal tributaries of the Rio Grande, but its normal flow is of less volume, although subject to greater maximum

THE PECOS RIVER.

floods. Irrigation from this stream never reached to any considerable amount until reservoirs were constructed, and its flood waters were controlled by two great dams, located above the town of Eddy, in Southeast New Mexico. The upper and larger of these reservoirs covers an area of 8,331 acres, and has a capacity of 82,640 acre-feet. It is known as "Lake McMillan." The dam, constructed in 1893, is 1,686 feet long on top, 52 feet high, with an auxiliary embankment 5,200 feet long, 18.8 feet high. The dam is composed of an embankment of loose rock, faced with an earth embankment of greater volume, the two having a total base width of 280 feet, and a top width of 20 feet. Its cost was $170,000. The lower dam is 48 feet high, 1,380 feet long, and is of the same type of construction as the upper dam—loose rock and earth. The lower dam has comparatively small storage capacity, but acts as a diverting weir to raise the level of water to the main canal leading down the valley. The canal carries 1,300 cubic feet per second for 3.2 miles, to a point where it divides into two main canals passing down each side of the valley. The town of Eddy, and a large and growing farming settlement surrounding, is dependent solely upon these two reservoirs. Here is located the only sugar beet factory in the territory, manufacturing sugar from beets grown by irrigation.

In the San Joaquin valley the normal stream flow still supplies the land brought under irrigation, without artificial storage, chiefly for the reason that, being fed by melting snow, they are highest during the early part of the irrigation season, although the need for reservoirs is being sharply felt, and there is a constantly recurring agitation on the subject. The only important private enterprise in this direction is the conversion of Buena Vista Lake, on lower Kern river, into a broad, shallow reservoir, by the wealthy cattle firm of Lux & Miller. An earthen dyke, five miles long, ten feet high, serves to enclose the lake, but the success of the enterprise is questionable, in view of the enormous loss from evaporation, which is estimated to reach as high as 130,000 acre-feet. This loss can be reduced to a fraction of this amount by storage reservoirs of greater depth and less surface area exposed, located in the mountains.

The investment in canals, lands, and improvements, depending solely upon irrigation from Kern river, is estimated at $6,000,000 to

$8,000,000, while the development of the waters of Kings and Kaweah rivers has created values many times greater than these figures.

IRRIGATION IN SOUTHERN CALIFORNIA.

In Southern California irrigation has reached a greater degree of refinement than elsewhere in America, because of the scarcity of water, the high value of the products grown, and the frequent combination of irrigation and domestic supply in one system. The waste of water in open canals by seepage and evaporation has led to the general employment of cement lined ditches for the larger volumes carried, or cement, vitrified clay or iron pipes for smaller quantities. The prevention of waste by these expensive methods has thus permitted an enormous increase in the duty of the flowing streams, and extended their sphere of usefulness. The building of small farm reservoirs has gone steadily forward with the growth of the industry, until the farm or orchard which is not thus supplied is the exception rather than the rule. This has increased the general cost of water to consumers, but has at the same time increased the productive area by adding to the economic measures for waste prevention. These individual reservoirs, however, are in no sense a substitute for the larger and more expensive impounding dams needed to regulate the streams and control floods.

The first of these of any importance to be constructed was the Bear Valley dam, built in 1883. At that time the site was well nigh inaccessible by wagon, and the cost of cement at the dam was so great as to induce the projector to cut down the dimensions of the dam to what is unquestionably the slenderest structure in the universe of equal height. It has special interest to the engineering profession in that it is capable of withstanding the pressure against it, and yet it has continued to defy preconceived theories for thirteen years. It is 64 feet high, and barely 3 feet thick at top, and but 8 feet thick at a point 48 feet below the crest. It relies solely upon its arched form for its support, and upon the fact that it is of a superior quality of masonry. It is reported to have cost $75,000, although it contains but 3,400 cubic yards of masonry.

The capacity of the reservoir is about 40,000 acre-feet, and the watershed area about 56 square miles, from which the run-off reaches an estimated maximum of 100,000 acre-feet. The maximum run-off of the dry season of 1898-99 was less than 1,000 acre-feet.

Sweetwater Dam, in Southern California.

THE SWEETWATER DAM.

In 1887-88 the Sweetwater dam was constructed, on the Sweetwater river, twelve miles southeast of San Diego, on a stream from which no irrigation was possible prior to the erection of the dam, because of the fact that it was generally dry every year after June 1st. The dam is built of masonry, founded on porphyry bedrock, at a point seven miles inland from the bay of San Diego, at an elevation of 140 feet above tide. The height is nearly 100 feet; length, 150 feet at base, 350 feet at top; arched up stream similarly to the Bear Valley dam, but of much heavier section, being 46 feet thick at bottom and 12 feet at top.

The reservoir had an original capacity of 18,000 acre-feet, enlarged in 1896 to 22,866 acre-feet, and is fed from the run-off of 186 square miles of watershed, whose extreme elevation is about 6,500 feet. The mean annual run-off from 1888 to 1896 ranged from 1,007 to 70,625 acre-feet, averaging 18,708 acre-feet. The drought of the past two years has failed to replenish the reservoir, and its supply in the summer of 1899 is quite exhausted, and reliance is had upon water pumped from wells.

From the dam water is conveyed and distributed through iron pipes, over an area exceeding 5,000 acres, planted chiefly to lemon orchards. The cost of the dam and distribution system has exceeded $1,000,000, but it has added many millions to the wealth of the county. It is a striking illustration of pure development of water from a stream that had been useless and valueless without the reservoir.

THE CUYAMACA RESERVOIR.

A similar case of the conversion of a useless stream into one of usefulness and value is that of the Cuyamaca reservoir, built in 1887 by the San Diego Flume Company, for the irrigation of mesa lands lying east of San Diego, and the supply of the city of San Diego. This reservoir is located in the Cuyamaca mountains, at an elevation of 4,500 feet above sea level. It is formed by an earth dam, 41.5 feet high, and has a maximum capacity of 11,410 acre-feet, covering 959 acres of surface. It has a tributary watershed of but 11 square miles, which greatly restricts the usefulness of what would otherwise be a very valuable reservoir. Up to 1896 the minimum annual catchment was 1,158 acre-feet, the maximum 11,464 acre-feet, and the mean 5,397 acre-feet. The evaporation loss was a mean annual depth of 4.73 feet, amounting to 25.5 per cent. of all the catchment entering the reservoir.

The area irrigated by the reservoir prior to 1898 is given at 5,700

acres, for which a portion of the supply, estimated at 16 per cent., was taken from the direct flow of the other tributaries of San Diego river, while the reservoir was filling. One-fifth of the water supply of the system is used for the domestic supply of San Diego, and the remainder for irrigation. The water is conveyed in a wooden flume, 5 feet wide, 37 miles long, supported on a level bench cut in the hillsides, or on high trestles crossing depressions. It delivers water to the pipe system ten miles east of San Diego, whence it is distributed in iron pipes under pressure throughout the irrigated settlements supplied.

THE LA MESA DAM.

At the lower end of the long flumes a reservoir has been constructed on the mesa at an elevation of 433 feet, which serves to impound the surplus flow of the flume, and catch the run-off of a small local shed. The reservoir covers 70 acres, and has a capacity of 1,500 acre-feet. The dam was built by the hydraulic sluicing method, by which the material composing it was loosened, conveyed and deposited by water, which was afterwards caught in the reservoir behind the rising dam. This is one of the most interesting structures of its class in the country, and illustrates a simple and cheap method of building dams of earth and loose rock. It contains 38,000 cubic yards, and was built for $17,000. It serves a useful purpose in economizing the water and in its distribution.

The cost of the entire irrigation system, including the long flume, was nearly $1,000,000.

THE OTAY AND MORENO DAMS.

All of the streams of San Diego county have the characteristics of intermittent flow, which renders them practically valueless except when their floods are controlled and impounded by reservoirs, but they have the compensating advantage of possessing reservoir sites of unusual capacity and excellence. Two of these sites have been utilized by the Southern California Mountain Water Company, by the erection of imposing dams of unusual height on the Otay creek, in Jamal valley, and on Cottonwood creek, at the outlet of Moreno valley, while a third, designated as the Barrett dam, is under construction at the junction of Pine and Cottonwood creeks.

The lower Otay dam is located some five miles southeast of
14 Sweetwater dam, and is an embankment of loose rock, 130 feet high,

Turlock Dam, Toulumne River, California.

with a central core of sheet steel, in the form of plates riveted together and imbedded in masonry at bottom and on either side, connecting it with the bedrock abutments. The dam is 565 feet long, 20 feet wide on top, and contains about 140,000 cubic yards of rock. It forms a reservoir covering 1,000 acres, and having a capacity of 42,190 acre-feet. The tributary watershed has an area of 100 square miles, but with a run-off which cannot be relied upon to fill the reservoir with frequency or regularity. It is necessary, therefore, to construct an expensive conduit 11 miles long, from the Cottonwood, to bring a supply to the reservoir. This conduit is to have a capacity of 220 cubic feet per second, and will head at the Barrett dam, some 50 feet above the base of the latter.

The Moreno dam, which is still unfinished, will have an extreme height of 150 feet, and is of similar character to the lower Otay dam, except that the embankment is to be made watertight by a layer of asphalt concrete upon its upper face, connecting with a concrete toe wall that extends to bedrock at the bottom of the dam. The elevation of the dam is 3,100 feet above sea level, and has a tributary watershed of 135 square miles, reaching to an extreme elevation of over 6,000 feet. The capacity of the reservoir at the 150-foot level is 46,733 acre-feet, extending over 1,370 acres of surface.

The Barrett damsite at the 160-foot contour has a capacity of 35,160 acre-feet. The dam to be erected is similar in plan to the lower Otay.

These three reservoirs are to be united in one system, and supply water for irrigating lands lying between San Diego and the Mexican border, consisting of high mesas and valleys reaching back some ten miles or more from the ocean. The rolling nature of the topography, as well as the economical use of water, will necessitate its conveyance in pressure pipes of iron and wood. The city of San Diego, as well as Coronado Beach, will receive at least a portion of its domestic supply from these sources.

THE ESCONDIDO DAM.

In the northern portion of San Diego county lies one of the fairest valleys of California, whose character is implied by its Spanish name, Escondido, (hidden), surrounded and sheltered by rugged hills. Some 13,000 acres of this valley, including the town of Escondido, was organized into an irrigation district under the Wright law, and in 1894-95 constructed a notable dam in the adjacent mountains, to which was brought a water supply from the San Luis Rey river, through a canal

Dam for Irrigation, Arizona.

and flume 15.6 miles long, tapping the river at an altitude of 1,600 feet. The conduit has a capacity of 28 second-feet, and cost $116,328. The dam is a rock-fill, faced with plank, [illegible] feet high, 380 feet long on top, 100 feet at bottom, with a top width of 1[illegible] feet and a base of 140 feet. Its cubic contents are 37,159 yards, and its cost complete was $110,059. The reservoir covers an area of 150 acres, and has a capacity of 3,500 acre-feet when filled to the level of the spillway.

Distribution is made by cemented ditches, flumes and pipes. The entire system of works cost $352,500. The lands irrigated are chiefly planted to citrus fruits, and exceed 2,000 acres.

Prior to the construction of the works no use had been made of the water of the San Luis Rey except in a small way by the Indians living along its course at the Cuca reservation. To the extent of their needs, the prior rights of the Indians are still respected, and only flood waters are diverted to the reservoir.

THE HEMET DAM.

On the flanks of Mt. San Jacinto, one of thee loftiest peaks of Southern California, whose crest reaches to a height of nearly 11,000 feet, lies Hemet valley, whose outlet through a narrow granite gorge has been closed by the erection of a masonry dam 122.5 feet high above the stream bed. The altitude of the dam is over 4,200 feet, and the difficulties of transporting machinery and cement to the site were very great; but the structure resulting from the efforts of the Lake Hemet Water Company is one of the most massive and perfect structures ever built, surpassing in safe dimensions all similar works on the Coast.

The reservoir covers 365 acres, and the volume impounded when filled is 10,500 acre-feet. Water released at the dam flows down a natural canyon some ten miles, descending 2,000 feet in a succession of cascades, and is then diverted into a flume 38 inches wide, 18 inches deep, built down the canyon to its mouth, 3¼ miles, on a grade of 140 feet per mile. Thence it is taken in a 22-inch pipe for two miles, and delivered to a ditch lined with masonry, having a capacity of 3,000 miner's inches, leading to the distributing reservoir, five miles. From the latter, sheet-steel pipes convey and distribute the water to irrigated lands and to the town of Hemet. The full duty of the reservoir has not yet been reached, as the area irrigated has never exceeded 1,200 acres. The district is one of great thrift and fertility, and the orchards of deciduous fruit trees and olives have made phenomenal growth.

Irrigating Tunnel and Flume, San Diego County, California.

The works have reclaimed a tract of 7,000 acres from a desert to a condition of high productive capacity.

In addition to the greater works here described for the impounding of water, many other worthy projects are outlined and contemplated of a similar character, and it is felt that such development has only fairly begun.

It may be said that every canyon affording a living stream in Southern California has been appropriated and its waters put to use, while the springs and cienegas have been opened out and developed by cuts, tunnels and bored wells. Not only this, but in all the important water courses issuing from the mountains, the underflow has been sought after, and the subterranean supply brought out by extensive systems of tunnels. This method of development is not confined to the canyons, but tunnels have been driven into the sides of the mountains to intersect ledges or across dykes that intercept the percolating streams filtrating through the rocks.

SUBTERRANEAN RESERVOIRS.

On the three principal rivers of Southern California, the Los Angeles, San Gabriel and Santa Ana, nature has formed subterranean reservoirs of unknown capacity in the gravel beds formed by the debris carried out from the mountains. These gravel reservoirs are periodically filled, and the flow from them is constant and remarkably uniform. The Los Angeles river reservoir yields in this manner from 4,000 to 5,000 miner's inches, all of which is diverted for the uses of the city and the irrigation of adjacent lands. The San Gabriel river reservor overflows in the narrow pass of San Bartolo, where the stream goes through the Coast Range, and gives up in the aggregate some 5,000 inches,which is used for irrigation in numerous ditches in the Rivera and Downey district.

The Santa Ana river reservoir is divided into two sections, one of which supplies Riverside, Agua Mansa, and North Riverside, while the lower division yields up its flow at the passage through the Coast Range, whence it is diverted in canals to Orange, Tustin and Santa Ana on the south, and Fullerton and Anaheim on the north side of the river.

The aggregate yield of these two natural reservoirs is in excess of 10,000 miner's inches, and to their existence is due the prosperity of the populous regions they supply. If these rivers flowed in rocky beds from the mountains to the sea, they would be quickly exhausted,

Cuyamaca Reservoir, California.

and in seasons of drouth would be destitute of water. Thus nature has again demonstrated her superiority to the works of man.

Every inhabitant of Southern California is conscious of the fact that all of her productiveness and capacity of supporting population rests upon her resources for irrigation by some one of the many systems of development described in the foregoing sketch, and that without irrigation the country would be practically uninhabitable, except in seasons of abundant rainfall, when grain crops are produced. The natural rainfall would not, however, sustain her prolific orchards, from which comes her chief source of wealth. They are equally conscious and alive to the fact that our water sources depend in large measure upon the preservation of our mountain forests, and in this conviction there is no division of opinion.

CHAPTER XXVII.

THE UNDERGROUND WATERS OF SOUTHERN CALIFORNIA.

By T. S. VAN DYKE, Civil Engineer and Author.

The discovery of water underground available for irrigation at prices that the products of Southern California will justify is nothing new and its development has been going on for years. But the amount found in the past year just after a series of six years of short rainfall, of which four were only about one half the average, and the other two not above it, exceeds all that has ever been imagined and is possibly equal to the total of all other years combined.

Nearly all of this development has been in the four counties of Los Angeles, San Bernardino, Riverside and Orange where the older orange orchards in full bearing made such a demand for water to mature the present great crop. These four counties once lay in the lap of a crescent of granite mountains which were then far higher than they are today, and the whole country from coast to mountain was also higher. All lay open to the sea and the whole drainage downward was uninterrupted from the mountains to the coast. As the mountains began to disintegrate and wear down and the valleys to fill up with the wash, the heavier discharges of flood years carrying gravel and heavy boulders far down the slope began to arrange their debris exactly as we see them doing today. They swung from side to side to of an immense flood plain, one river perhaps running into another at times of great flood. Here the track was a vast wash of heavy gravel which, in succeeding years, became covered with fine sand if the flood waters moved to the other side of the valley, or with fine wash if they stayed on that side but were not so heavy for a series of years.. Or if the waters of summer and succeeding years continued to flow over them they became covered with fine concrete lime or silica carried in solution. As in the course of ages they became covered with other layers some of the layers of sand or gravel decayed into clay just as they lay. By some or all of these ways layers of gravel which were once old stream beds, became separated from one another by layers of impervious material.

They became farther separated by shifting from one side to the other of the great valley in different ages, just as we see them doing today. The consequence is a vast number of different gravel channels of different sizes, depths and distances from each other.

Most of these are probably still connected with the original source of supply by a thread of gravel or sand, while some have a well defined channel directly connected with the water that sinks at the foot of the mountains today. While it is impossible to say how large any of these are or how much water they contain, it is certain that their number is very large. The area through which they have swung is so great and the period so immense that it cannot be otherwise. It is reasonable to suppose that the older ones formed when the mountains were highest and the wash into the valleys was the coarsest now carry the most water today, although most of them must be out of reach of all ordinary well boring.

In the course of time and probably long after the valleys began to fill, the country sank and a part became lower than the sea. Then came in a vast wash from the west or north, or both, perhaps from the melting of the great northern glaciers. This brought in vast banks of gravel, sand and clay and other deposits far more recent than the granits of the interior hills. In San Diego county this formed a mesa some fifty miles long, ten mile wide and nearly five hundred feet high, lying along the coast. How deep it is no one knows, but in the Sweetwater Valley, five hundred feet below the highest levels of the mesa, a well was bored eleven hundred feet without going through it. This would make it over sixteen hundred feet thick at that point. In Orange county this formed the hills of shale that lie along the lower coast, which have since decayed upon the top into adobe. Its oldest form is probably in the conglomerate that lies across the mouth of Santiago Canyon, running many miles up the canyon, and reaching some distance on each side of it. Back of Whittier and Fullerton this runs into hills of shale again, and these continue on to Los Angeles, running on the west and south into gravel, sand and clay deposits, but all of the same general formation. On the northwest and west they run into the granite of the Cahuenga hills, and these again into conglomerate of an older date in the Santa Monica mountains, changing into an older conglomerate in Ventura, and from there continuing along the coast of Santa Barbara.

Nowhere east of its course is there any track of its path showing

that any of it came from the great mountains of the interior. On the contrary the sand and gravel it contains are so full of porphory, finer sandstones and shales that it is certain that it did not come from the granite ranges on the east. It has also penetrated the interior as far as Redlands where a vast bank of it underlies the present top soil of that place. This seems a continuation of the Puente hills which are found about Pomona traceable again at Colton, south of Redlands, it crosses San Timateo Canyon and runs nto the grey hills of lime shales that lie on the northern edge of San Jacinto.

Commencing far in Lower California, a range of porphory rises a few miles from the coast, crossing the line at San Isidro, and forming the ledge on which the Otay Dam is built, doing the same for the Sweetwater Dam and the La Mesa Dam of the San Diego Flume Company, crossing the lower edge of Escondido, and continuing on through Santa Margarite, forming the great backbone of the hills between Santa Ana and San Jacinto and sinking at Santa Ana Canyon. Where the conglomerate laps upon this in the upper part of Santiago Canyon, the uplift of many miles of it shows plainly that the conglomerate was formed before the porphory rose. In parts of San Diego county it is just as plain that the conglomerate was washed in afterward and lies in position against the slopes of the porphory.

These formations and the various layers itself compose all the geological features of that portion of Southern California west of the desert.

Now it is certain from many borings that old water channels lie beneath this immense wash from the west and that the streams once ran beneath where we now see nothing but hills. The water that supplies the artesian wells between Whittier and Fullerton on the dry mesa never comes from the local watershed of those low hills back of the mesa. The Santa Ana, the San Gabriel or the Los Angeles rivers—(perhaps all three of them)—in some distant day had one or more channels running over a broad valley that is now covered by those hills. That wash turned the main body of the stream but the gravel of the old channels still continued to carry water.

It is almost equally certain that water from the Santa Clara River enters San Fernando Valley under the range of tertiary in which the Southern Pacific tunnel is built. A little to the west of the tunnel the granite begins, but from there west the hills are all wash. And there is more water at the head of San Fernando than the local watershed can reasonably explain.

In many other places this is found so plain that dry hills of this tertiary or wash may have better underground streams than the more recent wash of the open valleys where we would naturally look for water. The well would generally be more expensive on account of the depth and the boring seems a little more of a venture than in the open valley but otherwise there is little difference, except where water under pressure is plainly indicated.

It is equally certain that water channels lie upon top of the first wash and below a more recent one. Remarkable finds of water have been made at Redlands this year in low hills, so dry that no one would dream of looking for water there. One well gives one hundred and twenty inches, while another one but a hundred feet away yields eighty to the pumps without being affected by the pumping at the first well more than seven inches. These are in gravel channels unuer the present surface soil which seems a wash or slump from Yucaipe and San Gorgonio. At four hundred feet one well struck the old wash, which is the same hard conglomerate as that at the mouth of Santiago Canyon, and penetrated it eighty feet, finding it as hard as flint and perfectly dry. All the water strata are above this.

The results of many hundreds of borings, made all over the country show that the best chance to get a well that will furnish a good irrigating supply is in the modern wash of which the valleys are now composed. One cannot always be sure of hitting it even here, but with the right kind of care the chances are better for a cheap well than elsewhere. We see this wash going on every wet year and many have seen good springs completely drowned with it so that there is no sign of their existence on the surface. Even lagunas were drowned in 1884. In the dim past this must have happened often and those same waters are there now only in sand instead of an open reservoir.

Next to this wash the old channels under the hills of tertiary, or most ancient wash, are the best source of supply, such as the great gas well near Santa Fe Springs. This pressure was quite plainly indicated by Fulton Wells, which is as clear a case of artesian spring as one could wish. There are many places far more promising than the dry hills about Redlands that have never yet been prospected with any care. But such prospecting is so expensive that if we have a series of good years there is not likely to be much of it.

These old gravel channels are the only ones that have a reliable supply of any size. There are many cases where sand wells may be

made that will furnish considerable seepage water if not too heavily drawn on. But they will not stand heavy work very long. It is much the same with mere standing water in gravel. There is, however, very little of this and it is doubtful if we have anywhere water underground so nearly at rest that it would be called percolating water by our courts.

The decayed granite that lies upon the hard core of the granite hills is one of the surest sources of supply for a small well. For domestic use and a very little work with a windmill they are quite cheap and reliable in most seasons, holding out in years of drouth wonderfully if not too heavily drawn on. But they are of little use for heavy work in irrigation but rather a vexation and a loss.

It is much the same with wells bored into the hard core of granite below the rotten top. Unless a seam is struck there is no chance for water and when one is found that furnishes good water it cannot be relied on for much beyond domestic use. I know of no artesian wells in hard granite and any attempt to get one would probably fail. Even finding a seam is quite accidental and I have known many to fail to find that.

The porphory is one of the most difficult formations in which to find irrigating water. And it is none too good for domestic water. It is fissured perpendicularly so much that the water falls through it. Most all attempts that I have known to get a good well in it have failed. I know of none that flow under pressure and have seen holes made in it that were perfectly dry at over one hundred feet. At the same time it is certain that water goes through the ledges of it on which the Sweetwater dam and the old Mission dam at El Cajon are built. And in Lower California on the San Domingo river are several ledges that look solid enough to cut off the underflow, yet there is as much water just below them as above.

Even worse if possible than the porphory is the ancient wash from the west. There is little hope of getting anything in it more than a fair farm well, unless the boring is carried through it into some old gravel channel beneath. The most solid looking conglomerates, such as that in Orange county and the southern part of Ventura, as on the Simi Rancho, are so fissured up and down that the water can drop through them very readily. And one may often travel miles without finding a single spring where in granite of the same elevation and rainfall springs could be found in almost every gulch.

There is positively no ground for the belief that any of our underground waters come from anywhere beyond the rim of our own mountains. Many think there are underground rivers from the Sierra Nevada or the Rocky mountains, while others are sure that the Mojave finds its course back from the desert under the mountains of San Bernardino. Resort to all such theories is very unscientific if there are conditions nearer home that will explain the facts as well. There is positively no need of going beyond our own watersheds to account for all the water underground and far more than has yet been brought to light.

Consider first how wide these ancient valleys are. The best part of Orange county and some two-thirds of the coast line of Los Angeles county was once a flood plain over which the Los Angeles, the San Gabriel and the Santa Ana rivers gamboled for long ages, changing places with each other probably as we have seen them do to some extent in our own time, but certainly shifting their beds with every fresh burst of heavy flood water. Each one has made hundreds and even thousands of channels and bed of gravel, miles away from one another and no well has yet passed below the bottom layer, though many have gone over a thusand feet. The same thing has happened on smaller scales with other streams. The effect is to make countless reservoirs that will hold many times the amount of water we have seen developed. The outlet to the ocean from these cannot be very free or they would not have remained so full during all these dry seasons.

Is there water enough from the rain to fill them? In very wet seasons some of the rainfall from the low country probably finds its way into them while the mountains turn in some even in ordinary dry seasons. In wet seasons the quantity turned off from the mountains is so great that a very few winters would fill all the underground channels. Once filled, with plenty of friction to fight on the way to the ocean, the water would remain in these with a far smaller supply than was necessary to fill them in the first place.

As resources in dire necessity these old channels are a mighty blessing. They have actually saved this year one of the very finest of our settlements and insured nearly a million dollars worth of oranges where from the failure of a great reservoir would have been almost nothing. They have helped out many another settlement that would have been mourning over a short crop while individuals

by the hundred are rejoicing in prosperity who would have nad absolutely nothing but for the old streams that flowed unsuspected beneath the ranch.

From the very nature of these streams, one can understand the absurdity of attempting to say how long they will continue to furnish water if steadily drawn on. But one thing can be definitely known. And that is if they are reserved for emergencies like the present they will be full enough when we need them. But if drawn on all the time it is certain that some of them will not be full when the emergency comes. How long will it take them to fill when once exhausted I am not bold enough to guess. The time will vary with almost every one. How many taps an underground stream will stand for even one year is a question that one will hesitate to answer if he will for a moment consider the formation of the gravel beds and how they are cut off one from another or connected only by a thin thread of gravel, or even fine sand, and how they may be connected in the same way even with the main source of supply. We know not how long it took them to fill in the first place and we know as little of how long it will take if they are once emptied. But it is quite probable that the time required will be far greater.

It is, however, certain that for the maintenance of these supplies the preservation of the forests is quite as essential as for anything else. The inlets to these great beds of water bearing gravel and sand are small and thin, and covered often with soil so that it takes much time for the water to soak into them. To fill them needs a long, slow run of water. Quick discharges simply pass over them and let in very little. If the water from the mountains is laden with fine silt and slime from fire burned ground these inlets tend to puddle and close and in the course of time it would take much longer to fill the old gravel reservoirs than now, while many of them might in that way be closed almost completely against even the slowest run of water.

CHAPTER XXVIII.

FOREST RESERVOIRS.

By GEO. H. MAXWELL, Ch. National Irrigation Com.

A flowing artesian well!

Stand and watch it.

See the glistening sheet as it cures so gracefully over the rim, sparkling in the sunlight as it falls and flows away to moisten the parched earth and quench its thirst.

Could anything be more beautiful—more potent with promise of all the gifts that bountiful nature showers upon him who tills the soil by irrigation?

Or go where you will see the crystal stream gushing forth from some great pump that is steadily drawing it up from a hidden reservoir.

In either case, watch the water as it flows.

Where is its source?

Whence does it come and how long will it continue?

Will it keep on coming forever? Or some day will it grow less and less until it ceases altogether, and leaves the beauty and fertility and wealth that it has created to be blighted and destroyed by drouth?

Every irrigator from an underground source and every community sustained by such irrigation is face to face with this question. Its mighty importance may be realized when we read the midwinter number of the Los Angeles Times for January 1, 1890, that

"There has been an immense development of water for irrigation in wells during the past year, the amount so developed being estimated at over 50,000 miners' inches, sufficient to irrigate 500,000 acres of land. In this way the value of such land has been increased several hundred per cent. The work of developing the underground water supply still goes forward and in few cases are the prospectors disappointed."

These great underground supplies of water are as inexhaustible as the forests of the mountains are enduring, unless wilfully destroyed

by the hand of man, and so long as the forests are preserved the underground flow will continue.

Destroy the forest cover of the mountains and not only will the surface streams be deprived of their summer flow, but the underground supplies will no longer be replenished and will fail, and the desert will resume its sway over the lands that were fertilized from the exhausted underground sources.

The original source was not underground. As you watch the artesian well you will realize that the beautiful drops that are thrown up from below by an unseen power to sparkle in the sunshine have not come up underground direct from the sea. They were at some time evaporated from the ocean and carried in clouds to the mountains and precipitated there. Now what checked them from rushing down the mountain sides and back through stream and river to join again the ocean from whence they came?

Somewhere in their onward course they were stopped by some leafy covering which held them until they were turned downward into the earth. Then they percolated through some underground channel or strata until they found a vent through the artesian well that has brought them once more to the surface.

If we allow our mountains to be deforested and permit the destruction of the undergrowth and foliage, the waters which should find their way down into the earth to come up again in our wells will rush down the steep and bare mountain slopes in torrents to the sea. Not only our underground supplies but our surface supplies as well will be gone. and aridity will overcome our fertile fields just as it has where the forests have been destroyed.

This need not happen and will not happen if the people will wake up to the possibility and danger of loss of water supplies from forest destruction. If we are to preserve the water we must preserve the forests.

The forces that are working the destruction of our forests are more dangerous than a foreign foe, because more subtle. A shot fired from a hostile battleship upon one of our seaboard cities would electrify the people of the nation and rouse them to superhuman efforts for defense.

Year by year our noble forests are being devastated by fire or some other destructive agency and water sources which are the very life of whole communities impaired or ruined and the great majority of people pay no more heed to a forest fire than they would to a falling star in the heavens.

The protection of our forests from destruction, and their restoration where already destroyed is as much a great national duty as the protection of our boundaries from foreign invasion or of our seaport cities from the sea.

Let us not spend for ships and forts all that we spend for national defense. Let us provide for protection against the deadly encroachments of the desert. A city ruined by bombardment could be far more easily restored than a forest destroyed by fire.

CHAPTER XXIX

RELATION OF STREAM FLOW AND SUSPENDED SEDIMENT THEREIN, TO THE COVERING OF DRAINAGE BASINS.

By J. B. LIPPINCOTT, Civil Engineer, Resident Hydrographer U. S. Geological Survey

Purpose of the work of the Hydrographic Branch of the U. S. Geological Survey.

The Irrigation Survey, under the management of the U. S. Geological Survey, was authorized by the following Act of Congress, approved October 2, 1888: "For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of irrigable land in such arid region, and for the selection of sites for reservoirs, and other hydraulic work necessary for the storage and utilization of water for irrigating, and the prevention of floods and overflows, and to make the necessary maps." This survey lasted until 1891, when a discontinuation of aprpopriations by Congress brought it to an end. One of its principal duties was the study of the water supply of the arid region. It was considered as important to find the manner in which the streams discharged as to determine the amount of the annual output. A stream of constant flow, and with few floods, largely eliminates the necessity for storage reservoirs thereon, the province of storage being primarily to catch flood water and hold it over for periods of drouth. Records were begun on numerous typical western rivers, and were maintained until 1891.

Appreciating the value of this work, Mr. F. H. Newell was retained by the Geological Survey to continue as many stream observations as were possible, but in 1894 the Director decided that it was impossible to set aside funds for this hydrographic work unless a special appropriation was made for that particular purpose by Congress. Mr. Newell at once energetically undertook the task of getting this appropriation to be expended under the direction of the Geological Survey. He was successful in obtaining $20,000 to be available during the fiscal year of 1895-6. The work has been gradually developed in all portions of the United States. It is evident that this work is closely allied to forestry. In addition to the question of lumber supply, the aim of forestry is to regulate the water supply. In an arid region this is the principal province of the forest.

Stream observations have been maintained and expanded particularly in the arid regions during the past five years. Discharge measurements are made almost entirely with meters. These meters are first rated so as to show the relation between the revolution of a wheel, which is immersed in the water, and the velocity of the passing water. By the determination of the velocity of a given stream, and its area of cross-section, the volume of flow is obtained. A gauge rod is placed at the point of measurement, which is called a rating station, and the height of water on this gauge rod is always noted in connection with the measurements. If the stream has a permanent channel, and observations are made at a number of different stages of river height, the relation between the height of water on the gauge rod and the volume discharged may be interpolated for intermediate river heights, and corresponding volumes determined. By reading the rod daily, daily, monthly and annual determinations of discharge may be obtained.

The results of stream measurement are published in annual reports by the Hydrographic Branch of the Geological Survey. There are also issued "Water Supply and Irrigation Papers," the purpose of which is to get quickly before the public the result of the year's work, pending the final and complete publication of the annual report. These documents can be obtained by application of parties who are interested in this subject to the director of the Geological Survey. The Twelfth, Eighteenth, Nineteenth and Twentieth Annual Reports are of especial interest in this connection. They describe methods and results in detail.

VARIATION IN STREAM FLOW.

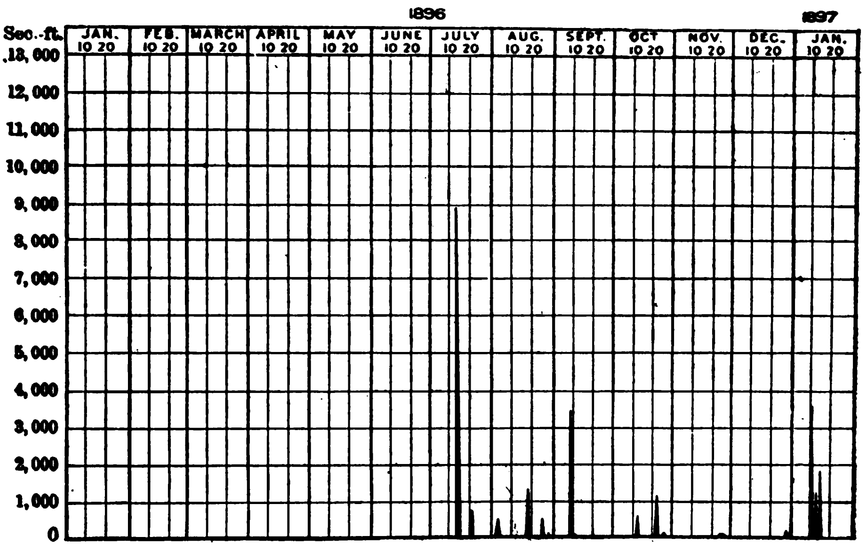
The relation of rainfall to run-off is very uncertain, depending upon the nature of the storms, whether gentle showers or violent rains, the steepness of the drainage basin and its covering, and whether the precpiitation is snow or rain. It has been found that in the districts where the forest cover is small the output of the basn occurs in violent floods of short duration. Because these floods are violent, and of large volume, and owing to the fact that the soil of the drainage basins is not held together by a network of roots, extensive erosions occur in these barren basins, and the water carries much silt in suspension. Where the basin is covered by forest the mat of twigs and leaves which covers the ground is an absorbent sponge, retaining in itself large quantities of water and preventing evaporation from the underlying soil. This permits of a holding back of the floods and the gradual draining off of the water, this largely accomplishing the purpose of regulating reservoirs.

An exception to the above conditions might be noted where a precipitous granitic drainage basin is expanded at the mouth of its canyon into a valley which, in turn, contracts at its outlet. This valley. during a geologic age, becomes filled with gravel and boulders. When a storm occurs on a drainage basin of this class, and the flood is projected upon these gravel beds, it is rapidly absorbed. The same absorption of irrigation water occurs on these valley lands. Slow percolation, or underflow, then follows towards the mouth of the valley, which has been more or less filled with water. At the lower narrows the regulated water again appears at the surface and produces a stream of great constancy. Even under this condition the forest cover of a drainage basin is important, owing to the fact that a constant flow is desired at the point where the water leaves the upper portion of the basin, and because floods often are discharged too large in volume to be wholly absorbed, and they in part pass completely over the gravel bed, escaping through the lower narrows, to be permanently lost. These conditions exist in the Los Angeles, the San Gabriel and the Santa Ana rivers, in Southern California.

A striking example of the output of a barren drainage basin is shown in the diagram of Queen Creek, Arizona, for the year 1896. In this diagram the vertical axis indicates volumes discharged, and the horizontal axis indicates time. This stream discharges only in violent freshets, recurring usually as great flood-waves, subsiding almost as rapidly as they arise. By making from two to three current-meter measurements of each of these freshets, and keeping an hourly record of the gauge height, the discharge can be approximated. The floods are usually not to exceed twelve hours in duration. During the greater portion of the year the channel is entirely dry. Queen Creek rises in the mountains to the southwest of Phoenix, and flows in a general southwesterly direction, losing itself in the desert north of the Gila River Indian Reservation. The area of the drainage basin is 142.5 square miles, of which 61 per cent is above an elevation of 3,000 feet, and 39 per cent below that elevation. The annual discharge is approximately 10,000 acre-feet. The basin is almost entirely bare, there being a few pinon trees and very little brush or grass. The following table of discharge for the year 1896 for Queen Creek is taken from the Eighteenth Annual Report of the Geological Survey, Part IV, Hydrography. It represents a typical year's output:

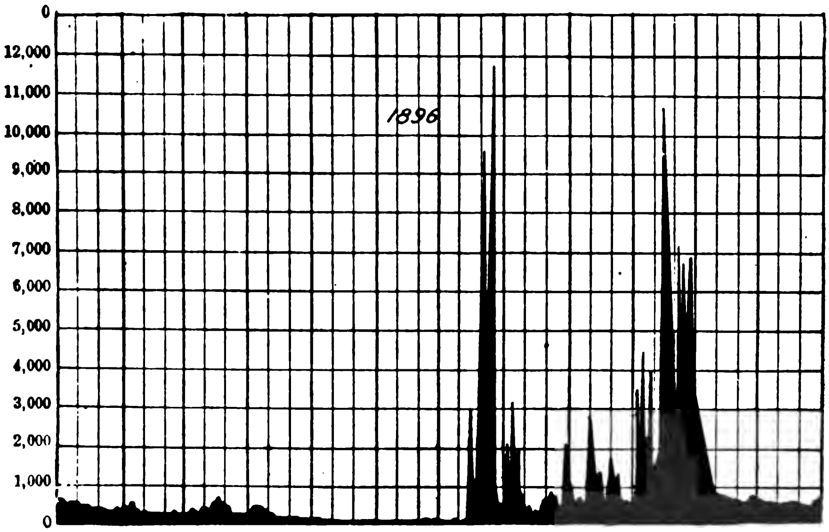
Estimated monthly discharge of Queen Creek at Whitlow's Arizona. Drainage area 143 square miles.

MONTH 1896	Discharge in Second-Feet			Total for Month in Acre-Ft.	Run-Off	
	Max	Min.	Mean.		Depth in inches	2d-ft. per sq. mile
January	2	2.0	2.0	123	0.016	0.014
February	2	2.0	2.0	115	0.015	0.014
March	2	2.0	2.0	123	0.016	0.014
April	2	1.0	1.5	89	0.011	0.010
May	1	1.0	1.0	61	0.008	0.007
June	1	1.0	1.0	60	0.008	0.007
July	9,000	0.0	121.6	7,477	0.980	0.850
August	1,433	0.6	13.1	805	0.106	0.092
September	3,428	0.5	17.1	1,016	0.134	0.120
October	1,188	0.5	13.3	818	0.108	0.093
November	80	0.6	1.3	77	0.010	0.009
December	207	0.6	2.0	123	0.016	0.014
Per annum	9,000	.0	15.	10,887	1.428	0.104



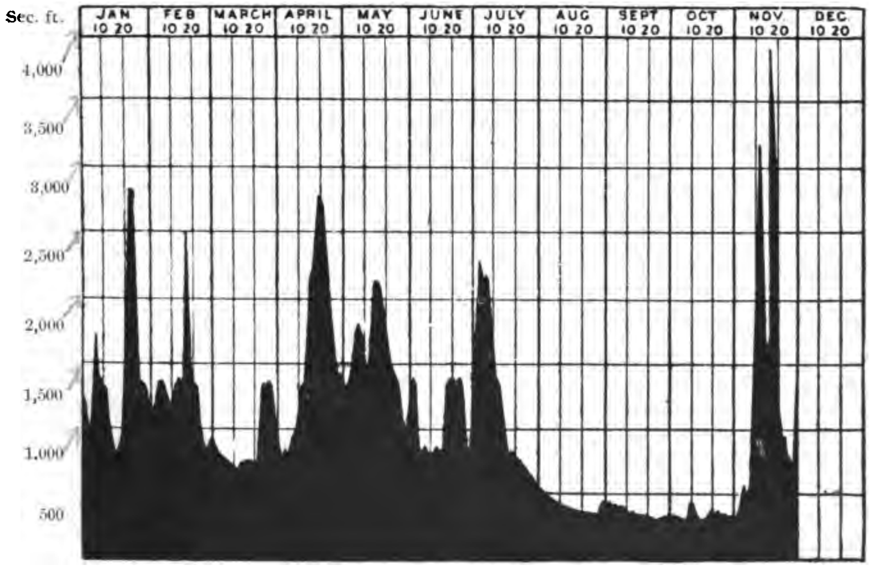
Discharge of Queen Creek at Witlow's Ranch, Arizona.

The basin of the Gila River adjoins Queen Creek to the south. Its general character resembles Queen Creek. As the area of the Gila River basin is 17,834 square miles above The Buttes, a general storm passing over it will produce a longer period of flood discharge, owing to the length of time it will require the water precipitated near the head of the basin to reach the point of measurement of The Buttes. A diagram is given of this stream for the year 1896.



Discharge of Gila River at the Buttes, Arizona, for 1896.

In contrast with the Gila River and Queen Creek in Arizona, a diagram is given showing the discharge of Cedar Creek, Washington, for the year 1897. The point of measurement of this stream is at Clifford's bridge, in section 19, town. 22 north, range 7 east, Willamette Meridian. The drainage area is estimated to be 143 square miles, and it, therefore, is the same as the area of the basin of Queen Creek. The basin of Cedar Creek lies on the western slope of the Cascade mountains. It is heavily timbered, and in addition the ground is covered with a very heavy growth of ferns and moss. The precipitation for the year 1897 was about 93 inches in the lower portion of the basin, and is estimated to have been as great as 150 inches on the mountain summits. The rainfall of the Queen Creek basin is estimated to be about 15 inches. The maximum flood discharge in 1896 on Queen Creek was 9.000 cubic feet per second, and the maximum flood discharge on Cedar Creek in 1897 was 3,601 cubic feet per second. The mean discharge for Queen Creek was 15 cubic feet per second, and for Cedar Creek 1,089 cubuc feet per second. While Queen Creek is frequently dry, the minimum discharge of Cedar Creek during the period in question was never less than 27 per cent. of the mean for the year. These two streams represent extreme types. The radical difference in their character is believed to be largely due to the difference in forest cover. The discharge of Cedar Creek for the year 1897 is believed to be fairly reprsentative. The



Discharge of Cedar River, near Seattle, Washington, for 1897.

following table of discharge is taken from the Nineteenth Annual Report of the Geological Survey, Part IV, Hydrography.

MONTH 1897	Discharge in Second-Feet			Total for Month in Acre-Ft.	Run-Off	
	Max.	Min.	Mean.		Depth in inches	2d-ft. per sq.mile.
January	2,812	815	1,430	87,928	11.55	10.00
February	2,415	823	1,303	72,365	9.49	9.11
March	1,366	723	901	55,400	7.28	6.30
April	2,752	790	1,599	95,147	12.47	11.18
May	2,143	939	1,562	96,043	12.61	10.92
June	1,410	780	1,060	63,074	8.26	7.41
July	2,284	57[illegible]	1,135	69,788	9.15	7.93
August	561	342	427	26,255	3.44	2.98
September	418	311	350	20,827	2.72	2.44
October	433	294	339	20,844	2.74	2.37
November	3,155	323	1,318	78,426	10.28	9.22
December	3,601	674	1,639	100,778	13.23	11.46
Total	3,601	294	1,089	786,875	103.22	7.61

It will be noted that the vertical scale showing the discharge is twice as large on the Cedar Creek diagram as on that of Queen Creek. If they were on the same scale the contrast would be greater.

Estimated monthly discharge of Cedar River near Seattle, Washington. Drainage area, 143 square miles.

SILT.

The amount of solid matter carried by a stream is a very serious problem in connection with the construction of storage reservoirs thereon. The most astonishing stories are told of volumes of sediment carried by the rivers of Southern Arizona from their barren drainage basins. It is said that when these floods first appear discharged off of ranges that have been travelled by the large herds of cattle in quest of grass, the soil, which is exposed to the direct action of the sun, being exceeding light and dry is washed off in quantities that are enormous. In order to determine the amount of silt in the Gila River at The Buttes, the Geological urvey has made observations by taking samples of the water daily, and permitting the mud to settle in graduated tubes. This amount of mud is then determined by reading its height upon the graduations. The mud which is deposited has then been treated in the case of numerous samples to a temperature of 212 degrees Fahrenheit, and the final amount of solid matter determined by weight. Observations were continued from July 29, 1895, to December 31, of the same year. Beginning on January 1, 1899, and continuing until July 31, 1899, similar observations were made at the same station, the amount of mud and solid matter being determined as previously. During the first period the volume of water discharged at The Buttes was 360,523 acre-feet, and it was found that this contained 37,984 acre-feet of mud in suspension. This reduced to 7,704 acre-feet of solids. The average amount of light sediment during this first period was 10½ per cent, and the amount of solids a little over 2 per cent. The total amount of water discharged during the second period in 1899 was 118,981 acre-feet, which containing 1.6 per cent of solids or 8 per cent of mud. Frequent observations were made, showing 20 per cent of mud in suspension during the high stages of the stream, and in one instance 27 per cent. of mud was observed. The average amount of mud for the twelve months' observation was 10 per cent., and the amount of solids 2 per cent. No other stream in the United States is known to carry such a high per cent. of mud sediment. This is in striking contrast with the clear streams of our northern forested basins. The water supply used for domestic purposes from Cedar Creek, Washington, does not require filtering or settlement.

The serious nature of this silt problem can readily be appreciated by those who have studied the storage of water for irrigation. It is probably the gravest of all the engineering problems related thereto. Forestry should assist greatly in removing dufficulties of this nature.

CHAPTER XXX.

FORESTRY AND ITS RELATIONS TO THE WATER SUPPLY OF SOUTHERN CALIFORNIA.

By A. H. Koebig, Consulting Engineer.

It is a common belief that the forests upon the watershed of any river have a great influence upon the water supply in that river, although, this belief being a general one, the facts must be enumerated in order to understand the reason why we should plant forests upon watersheds to protect our water supply.

The forests of Southern California are situated almost exclusively upon the high mountain watersheds of the streams. The north side of the mountains produces a very much denser growth than the Southern exposure. On the northern slopes at an altitude of about 3,500 feet above sea level we find the black oak, the yellow and sugar pines, the fir, cedar, hemlock and others of the family of the needle-bearing trees, also a luxurious growth of underbrush, consisting of ferns and mosses, while the southern exposure and the lower altitudes of the northern slopes only produce a spare growth of wild plum, scrub oak, manzanita, sage brush, grease wood and others of that class.

Our forests in the mountains have for many years past suffered by the continuous cutting of the trees for fire wood and lumber, and by frequent and extensive forest fires; also the herding of many thousands of sheep has destroyed the undergrowth and many trees. until it is almost impossible for the forests to recover, unless artificial means are employed to assist the same. This denuded condition of the mountains which constitute the natural watershed for our rivers and creeks has a most damaging influence on the water supply delivered to our valleys.

It is a well established fact that wooded mountains have a greater power to attract the clouds saturated with water and cause precipitation of the same. The forests on the mountains also moderate the

winds which have a tendency to shift the clouds before they have had time to give up their saturation in form of rain or snow.

The precipitation upon the surface of our watersheds is used in three different ways, as it were, viz.: 1st, for evaporation and plant life; 2d, for seepage into the earth, then collecting into surface, subterranean streams and gravel beds; 3d, for the storm run-off and run-off during the irrigating season.

FIRST—EVAPORATION AND PLANT LIFE.

There is a certain amount of the water precipitated in form of rain, snow and fogs upon the watershed which is taken up by the evaporation from the ground caused by atmospheric conditions, and also as nutriment necessary to sustain the plant life covering said watershed. This amount is varying with the conditions of the watershed, and also the atmosphere. Upon undulating surfaces in the valleys and foothills of Southern California we have learned by experience that ten to twelve inches in depth are necessary to maintain the plants and to supply the evaporation. However, on the mountains there is only from eight to ten inches required for this purpose. The waste caused by evaporation is, of course, greatly increased by high winds, also if the precipitation falls in form of snow upon an unprotected surface exposed to the sun on winter days and the winds sweeping over the open surface. In the latter case the evaporation becomes greater, and the major part of the entire snow fall will be lost.

SECOND—SEEPAGE INTO THE EARTH.

That portion of the rainfall which seeps into the ground beneath the capillary attraction finds its way into the underflow of the rivers and into the underground channels, saturating the gravel beds of the valleys and filling the strata carrying the artesian supply.

The saturated gravel beds feed the surface springs and supply the streams of Southern California, which after having disappeared from the surface reappear again and form a valuable part of our irrigation systems. The lower San Gabriel river is in summer entirely dry from the mouth of the canyon down to El Monte. At this place it reappears at the surface. Another instance of the same occurrence we find in the Santa Ana river, and many others of Southern California. The artesian supply is made up in the same manner, by the seepage of part of the rainfall falling upon the mountain watershed. This part finds its way through the strata which carries it on a

steep grade into the valleys and there delivers the same with sufficient force to rise upon or above the surface of the ground after being allowed a free passageway by a pipe inserted through the capping material of the stratum into the water-flow itself.

The amount available for the seepage into the underground channels cannot be measured, it can only be calculated as the remainder of the rainfall after deducting the amount necessary for plant life and evaporation, and also deducting the run-off which, under certain conditions, can be measured.

It is, however, very easy to see that the condition of the surface of the ground governs largely the proportion of rainfall which runs off quickly from the watershed and the proportion which is retained to seep into the ground. The rougher the surface of the ground is and the more porous we find the same, the more it will facilitate seepage into subterranean channels.

THIRD—THE RUN-OFF.

The run-off consists of the storm run-off and the summer run-off. The storm run-off is that part of the run-off which flows from the surface of the watershed after the upper crust of the same has been sufficiently saturated and no more water can be absorbed by it. This saturation depends not only upon the amount of rainfall and the time in which it fell, but also upon the character of the surface of the watershed. It is readily seen that if the moisture falls in torrents the surface of the ground quickly becomes super-saturated and the greater part of the rain runs off rapidly without having time to enter the subterranean reservoirs of the earth. It is also apparent that if the surface of the watershed is denuded of timber and underbrush, the storm run-off will be largely increased over the same from a well-timbered watershed upon which the trees and undergrowth form a resistance to the run-off and retain the water longer upon the surface, giving it more time to penetrate into the pores of the earth and subsequently into the subterranean channels and reservoirs which retain their water and give it up gradually during the summer into the streams or artesian supplies of the valleys. Of course, the more water we are able to save from the storm run-off and turn into the subterranean channels, the more we increase the usefulness of the watershed for irrigation.

The storm run-off from watersheds varies a great deal. Observation has shown that in Southern California it is as high as 95 per cent.

of the total run-off from the watershed, while from the eastern and from the wooded watersheds of the middle and southern Europe it is as low as 50 per cent. This is chiefly due to the condition of the surface of the watersheds, if we assume tnat the precipitation has fallen under normal conditions, excluding extremes, cloud-bursts, etc.

In order to make this clear to you I will compare the San Gabriel river with Lytle creek. The watershed of the San Gabriel river is greatly denuded, having only a very spare growth of trees and underbrush. The extent of this watershed is about 226 square miles; during the rainy seasons there are frequent and enormous floods in this river, while the normal summer run-off is only estimated to be from sixteen to twenty-two feet.

The watershed of Lytle creek is only about fifty-seven square miles, and is fairly well timbered, but it shows about the same average summer run-off as the above mentioned, while its storm run-off is considerably less.

The run-off from the watersheds depends largely upan the rainfall, of course, but it is not proportionate to the same.

Mr. F. H. Newell, of the geological service of the United States, has successfully attempted to show the relation of the ra'nfall to the run-off by platting the depths of the rainfall in inches, horizontally, and the mean annual run-off, vertically, which resulted in two curves, one showing the run-off from undulating surface and the other from the mountains. This is found in a pamphlet issued by the Engineers' Club, Philadelphia, Vol. 12, No. 2, July, 1895.

By decreasing the run-off from the watersheds, we do not only increase the direct supply in the rivers and artesian belts, but also increase the facilities for irrigation upon lands situated on lower altitudes in the drainage basins of the rivers. The water which is used direct upon the higher levels of the drainage basins will be detained by seepage into the ground and forced to the surface again at points further below. The amount which has not been used for plant life upon the first irrigated lands can be made available for irrigation at the lower levels. We see this demonstrated in the drainage basin of the Santa Ana river, San Gabriel and others.

I have tried to make clear to you how necessary it is to have the watersheds well timbered and covered with underbrush in order to create a good water supply for irrigation. We have, however, not alone to cause plantings of new forests, also it is of the highest importance to protect the now existing ones against their enemies.

The elements which largely destroy our forests are timber and wood cuting, sheep herding and forest fires.

While excessive cutting of timber or wood has a very bad result upon the quality of our watersheds, the herding of sheep and the forest fires can rightly claim to be the most damaging elements. Sheep will eat anything in their way and destroy all the underbrush, grass and small growth on the watershed. In this way they decrease the resistance of the surface against the running off of the water, increasing the storm run-off from the watershed—which latter is an entire loss to the irrigators. What is left after the sheep get through is generally destroyed by the fires left by the herders. Forest fires destroy all growth and prevent the young growth from coming up for years; also, the ashes created by the same will seal up the pores of the surface of the earth and seepage into the subterranean channels becomes an impossibility, while floods become frequent and destructive.

Again I will call your attention to the San Gabriel river and the forest fires on its watershed several years ago. After one of these large fires I have noticed that by a subsequent rainfall upon this watershed, a small flood resulted, showing that almost none of the water was absorbed by the surface of the watershed and all ran off in a very short time.

I have tried to express by the above statements the means of protecting our watersheds against the denudation, and to adopt such measures as are possible to create a new growth of trees wherever that can be done, and to replace the forests previously destroyed in order to increase the water supply for the valleys of Southern California, and, besides, if possible, to give an additional supply for such acreage as has not yet come under irrigation.

A. H. KOEBIG,
Consulting Engineer, Los Angeles.

CHAPTER XXXI.

THE RECLAMATION OF DRIFTING SAND DUNES IN GOLDEN GATE PARK.

By JOHN McLAREN

About 700 of the 1040 acres composing the reservation, was originally drifting sand that moved with every gale, heavy storms sometimes moving it to a depth of three feet in twenty-four hours. This sand is sharp and clean, with nothing in its composition of a loamy nature, barren and poor, so poor that barley sown on its surface, after being plowed and cultivated in a favorable season with plenty of moisture only grew about six inches in height and failed to perfect its seed, although perfectly protected from wind by a high embankment on its westerly side.

The first operation necessary in the reclamation of ground of this sterile nature, was to bind the sand to prevent its moving. Experiments were made by sowing barley, also by sowing seeds of the blue and yellow shrub lupin Lupinus Arborea, also by planting seeds of Pinus Maritima, all of which were partially successful, but the first complete success was with the planting of the entire area with the sea bent grasses (Calamagrostis Arenaria), which was done by planting the roots about three feet apart, and run in with the plow. A furrow was run about fifteen inches deep in which a few roots were dropped about three feet apart, then two furrows were turned in which no roots were set, in the third furrow, roots were again planted and so on over the entire tract. Where the dunes were too steep for horses to travel, pits were dug by hand, and roots planted the same distance apart as when the land was plowed, care being taken to firmly press with the foot the sand immediately about the roots. Moist or even wet weather is of course the best time to plant this grass, the best season for planting being between December 1st and February 15th. If planting be delayed much later, dry weather is apt to set in before the plants be-

come firmly rooted and the consequence is, many are lost either by drought or by being blown out by the winds.

Where any large areas of plants were blown out by the roots, care was taken to have the ground immediately replanted, a gang of men being sent after every storm to pick up the scattered roots and to plant them, if possible, deeper than before. The entire tract being planted with this grass, the next operation was the building of brush fences across the wind about 100 yards apart and from four to six feet in height on the sheltered side of which young seedling trees were planted, averaging five feet apart. A variety of trees were experimented with, among which were the Norway maple, which is so highly recommended in European works of reclamation, the Tamarix and the Poplar, the Monterey cypress, the Pinus Insignis, the Pinus Maritima, the Acacia Lophantha, the Acacia Latifolia and the Eucalyptus, Viminalis, Globulus, &c., all of which made satisfactory progress, excepting the Norway maple and the Poplar, the summer winds blowing every leaf off, almost as soon as formed. The Acacia Latifolia and Acàcia Lophantha, the Monterey pine, the Monterey cypress and the Tamarix are all about equally well adapted for standing exposed sea winds, and all seem to thrive equally well in the sand but we find that the barren sand does not contain nutriment sufficient to grow trees more than ten feet in height, or until the tree begins to form heart wood. About that stage of growth, the tree begins to show signs of distress, the leaves of the Conifers gradually grow shorter, the bark gets bound and the whole tree shows a stunted, starved look Acres and acres are now in that state, and unless given assistance will die outright. Several years ago, the work of fertilizing the forest trees was begun and wherever a load of loam, manure or other good rich dressing was spread, the hungry tree responded very quickly by making good growth, a more thrifty look was noticed and in less than a year they had a vigorous healthy look, showing that want of nourishment alone was the cause of their stunted appearance.

Now that the young Pines, Cypress, Eucalyptus, &c., are up twenty or more feet high, with good soil and plenty of water, most any tree that thrives in the neighborhood will do well. The willow, the elm, and the poplar, as well as the oak and the maple, are doing very well, and all the shrubs, such as rhododendrons, azaleas, and many others kinds.

MEMORANDUM FROM HON. WM. ALVORD OF S. F.

I do not believe that any one knows who was the first person to suggest the plan of reclamation of the sand dunes in Golden Gate Park and the Great Highway, which was successfully carried out by the Board of Park Commissioners, through its engineer, Wm. Ham Hall, who is now employed by the Russian Government in great irrigation schemes in Eastern Russia. In driving Louis Agassiz to the beach, over Old Point Lobos road, I remember making a diversion to the south, somewhere between Central and First avenues, to show him the sand dunes. I asked his advice about the treatment of them for park pur-purposes. He tore a slip off a newspaper and wrote the names of several French books (I have the memorandum pasted in my book of autographs); then said the subject had been studied by an able American author, our United States Minister to Italy, Geo. P. Marsh, who had published a volume on the subject called "Man and Nature." I think we all read it carefully, and were influenced by it

The first effort at reclamation were with barley and lupine seed sown broadcast on sand that had been turned over a little with cultivators. Children were employed gathering lupine seed several years. Afterwards we employed men in gathering the seeds of pines and cypress in Monterey county, which were sown in boxes in cool houses, and when fifteen or eighteen months old planted in the open under the protection of the lupines.

This was followed by the sowing of seeds of the Arundo Arenaria and other kinds (which we imported from France, "20 cases," and no doubt McLaren can give you the names) on the slopes of cuts and on the dunes oceanward from which the strong winds and drifting sands came. I may mention here that we had driven Asa Gray and Frederick Law Olmstead several times to the unimproved portion of the park, and were indebted to them for good advice.

The opinion is generally expressed that the intelligent and persistent work done on the wonderfully successful reclamation of the bare, drifting sand dunes of Golden Gate Park was largely due to Hon Wm. Alvord.

CHAPTER XXXII.

REPORTS ON FOREST FIRES FROM SPECIAL AGENTS

REPORT No. 1.

BY SPECIAL AGENT SENT OUT BY SOUTHERN CALIFORNIA FOREST AND WATER SOCIETY.

STODDARD'S CANYON FIRE.

This fire was first noticed Sunday afternoon about 2 p. m. from Santa Monica, and was started by a party of picnickers from Pomona who came to Stoddard's Camp. Some of the party went up the Canyon and several went up to the third Falls. When they wished to come back they had great difficulty in getting down the ladder on account of the fire below them. On arriving at the camp they gave the alarm and a very conflicting story as to its origin. U. S. Government Ranger Bradford has taken their names and addresses.

By Sunday night the fire had spread over the ridge around and over Spring Hill, along the ridge and over the Saddle of the Ontario mountain. Some work was accomplished by the force under Ranger Bradford, but the main reason the fire did not go over to the range leading to Old Baldy was the San Antonio Creek and Wash, which at this point is quite wide, with very little growth excepting that along the creek which is green. By Tuesday evening the fire had reached the western mouth of Cucamonga Canyon—thus doubling on itself. After reaching the Ontario Saddle it turned in a southeasterly direction and came down the canyon. At this point the fire could have been very easily controlled had the fire men been set to work to back-fire the canyon; but these tactics were not employed once during this whole fire. By Wednesday morning the fire had reached the eastern mouth of the canyon. On Wednesday morning, Rangers Bradford of San Antonio district and Casey of Lytle Creek started out with twelve men to Cucamonga Canyon in a wagon and took a cook and provisions. After taking the men to the canyon, Ranger Bradford took his team to Ontario.

In the meantime, Ranger Bradford sent a gang of eight men by way of the Fairchild's trail around to Mt. Cucamonga to intercept the fire; but as Ranger Bradford had never been over the Fairchild's trail he did not know that it had grown up in many places. The gang of eight men were, however, under a Mr. Norman Allen of North Ontario, who is a thorough mountaineer and has been over all the ranges in that vicinity; knew all the springs, Saddles and Hogbacks there were. Had Mr. Allen been given a man and two burros to pack provisions and water as far as they could go; had he also not been handicapped by orders from a man who did not know the mountains, the fire could have again been stopped here. But these men were expected to stop a mountain fire with three shovels, one pole axe and one hand axe. No files were provided them with which to sharpen these axes. One man was detailed to carry them provisions to the Ontario Saddle; instead of doing this he met us at the Forest Supervisor's camp and asked us to take them up, which we did. Now these men had worked their way to Cucamonga Mountain; reaching it, they were in no condition to work, for they had had nothing to eat since the night before and to get water they had to climb two miles down the canyon to a spring known to Mr. Allen, and not being allowed to back-fire there was very little for them to do, for it would be utterly imposible for them to cut a fire break wide enough across the mountain with two axes to keep flames back that jump two and three hundred feet at a leap.

My party reached the Ontario Saddle at 1:15 p. m. Wednesday, and sat down to watch the fire come up the Cucamonga Mountain. All the south and east was enveloped in dense smoke. If we could only have had some of the Washington officials there with us I am sure they would in the future try and do something to protect the reserves in a rational way. At 2 p. m. the flames burst over the peak with the roar of a water-fall, and these men would have been burned to death at their work had not Mr. Allen known the mountain and the course of the wind changed for the minute. As it was they had to drop their shovels, cover their mouth and nose with their coats saturated with water from their canteens and run over the side of the mountain. All this we saw from the Ontario Saddle. About two hours after this we met the men on the old Fairchild's trail, and a sorrier crowd of men I never want to see. Men who had been working and tramping over those mountains for almost 24 hours, with no provisions and their shoes worn into holes. We gave them the provisions and divided my whiskey flask among them, gave them tobacco, and one poor fellow, Mr. A. E.

Eidson, had to tie up his foot in a flour sack in which we took up their provision. In my estimation the man who will endanger men's lives by such ignorance is just as criminally careless as the fool with a match.

Ranger Casey deserves almost as much credit as Mr. N. D. Allen, as he started up the canyon after the fire, doing the best he could to save what the fire missed. He and his men saved the flume in Cucamonga Canyon. Out of the twelve men that started out with Ranger Casey only four came through, arriving at nine o'clock last (Thursday) night on Thursday's Overland. Forest Superintendent B. F. Allen arrived at North Ontario with a full outfit of shovels, axes, canteens and one brush hook. He told me he had just heard of the fire, and was very sorry that Mr. Borden, the Supervisor, had not telephoned him sooner. This will give you some faint idea of the way the men in charge of our reserves protect them.

From the time the fire started until it reached the big timber on the Cucamonga Mountain it is estimated that a large and important watershed has been destroyed. The big timber, which was reached by the fire on Wednesday, ranges from 4 to 6 feet in diameter and is from 100 to 200 feet high. The forest floor of these high Sierras is from 1 to 3 feet thick—pine needles, cones, etc.

On Friday morning the fire had gone to the east, north and south from Cucamonga Point. The fire had gone over Ice House Canyon and Deer Canyon. Lytle Creek is only a few ranges away, and unless stopped by rain or smothered by its own ashes it will go on to the desert, which would in that event have destroyed the eastern half of the San Antonio water shed. The entire Cucamonga water-shed, the Lytle Creek water-shed and the mountains in the vicinity of the Cajon Pass. The loss in that case would be at the least calculation, one-third of the entire Southern Reserve.

Respectfully,

CHARLES E. RHONE.

REPORT NO. 2,

BY SPECIAL AGENT SENT OUT BY SOUTHERN CALIFORNIA FOREST AND WATER SOCIETY.

FIRE IN SIERRA MADRE MOUNTAINS.

(Commencing Sunday, August 27.)

Origin of fire: Supposed to be caused by a party of picnickers from Pomona, who spent Sunday in Stoddard's Canyon. Some of the party went up to the third falls and when they started towards the camp could hardly get through on account of the fire. Upon arriving at camp they gave the alarm and told a very conflicting story. Their names and addresses were taken by Ranger Bradford of the San Antonio district. This was at 2 p. m. Sunday.

Methods of fighting the fire: At no time was there a systematic attack made. No line of campaign was laid out and no one was sufficiently well acquainted with the trails (Saddle, Hog-Back and Spring) of the mountains, in charge to do so. The only methods employed was one fruitless attempt to keep pace with the fire and save that which the fire missed. In this way twelve men under Ranger Casey of Lytle Creek managed to save the Cucamonga flume.

Mr. N. D. Allen of North Ontario, a trained mountaineer with eight men provided with three shovels and two axes, attempted to make a fire-break on top of the Cucamonga Mts., which resulted in failure and for which they almost lost their lives.

Tools used: All the tools used were borrowed for the occasion and none arrived from the Department until Thursday noon, when Forest Superintendent B. F. Allen arrived from Los Angeles. In the meantime the fire had gotten into the big timber northeast of the Cucamonga Mts:, and was beyond all hope of stopping it twelve hours before his arrival.

Men in charge: B. F. Allen, Forest Superintendent, of Los Angeles, is a man past middle life and is not fully acquainted with the Sierra Madre Mts.

Supervisor Borden of Pasadena is a man also past middle life; does not know the mountains, and did not attempt to get beyond the old

Richard Place in San Antonio Canyon, where he made his headquarters.

Ranger Bradley, who is game and fish warden as well as ranger, is also a man past middle life; he has never been beyond the Fairchild's trail.

Ranger Casey of Lytle Creek is a young and active man, and, considering that he was working in a district that he did not know, did very good work: starting out with twelve men up the Cucamonga Canyon after the fire and coming down the almost impassable Fairchild's trail at nine o'clock at night.

The commissary of the patrol was in charge of Supervisor Borden, and consisted of such scanty supplies that the men, when they could, would go to Stoddard's Canyon and buy their meals themselves. One man and a mule were supposed to transport provisions to the men, which he did, one meal at a time, while the men were ten and fifteen miles away.

FIRE PATROL AT STODDARD'S CAMP TUESDAY AND TUESDAY NIGHT.

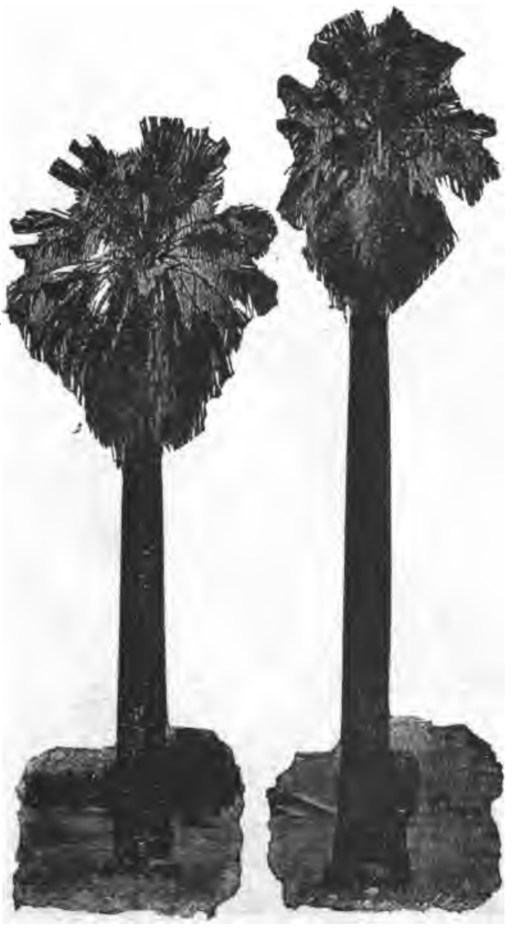
The men had fought the fire Monday night, and were relieved to rest Tuesday and Tuesday night; while the fire crossed from the west mouth of Cucamonga Canyon to the east mouth, not five miles away by wagon road, and could have been stopped by a few men by backfiring.

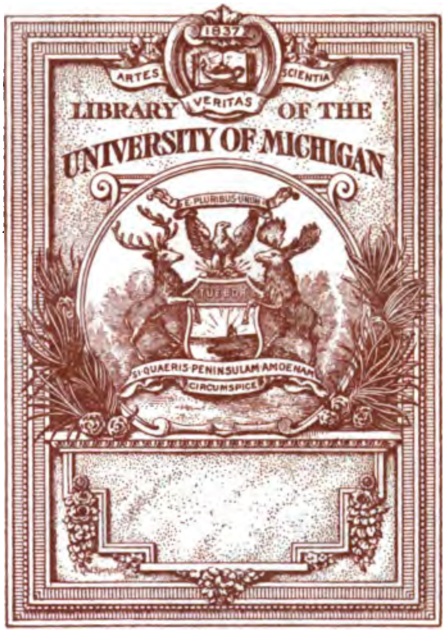
Age of Patrol. When Hon. Abbot Kinney asked Mr. B. F. Allen to employ the students of the Forestry School he replied that they could not use them as they were mostly boys. Now, the members of the Forestry School were with one exception over eighteen; while the patrol had two boys of fifteen and one man of almost sixty.

ILLUSTRATIONS.

INDEX.

FOREST AND WATER

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VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE